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SUMMARY DESIGN REPORT FOR THE PERT WALL AT
MONTICELLO UTAH DRAFT 2/99

6-4 **MAC–PTW 1.8**

Summary Design Report for the PeRT Wall at Monticello, Utah

Draft

February 1999

U.S. Department of Energy

Work Performed Under DOE Contract Number DE–AC13–96GJ87335 for the U.S. Department of Energy

mactec-ers
MACTEC ENVIRONMENTAL RESTORATION SERVICES, LLC

CONTRACT NO.: DE-AC13-96GJ87335
TASK ORDER NO.: MAC99-12
CONTROL NO.: 3100-T99-0442

February 2, 1999

Project Manager
Department of Energy
Grand Junction Office
2597 B¾ Road
Grand Junction, CO 81503
ATTN: Vernon A. Cromwell

SUBJECT: Contract No. DE-AC13-96GJ87335—Transmittal of Permeable Reactive Treatment (PeRT) Wall—Summary Design Report for the PeRT Wall at Monticello, Utah

Dear Mr. Cromwell:

Attached are 8 copies of the subject report. This report is not listed as a Task Order deliverable. It was developed as background information to the "Design Specifications for the Monticello Millsite PeRT Wall Groundwater Demonstration Project" delivered to DOE in mid December 1998.

If you have any questions, please call me at Extension 6588.

Sincerely,

Clay E. Carpenter
Project Manager

CEC/djd
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Information Repository/Administrative Record
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Permeable Reactive Treatment (PeRT) Wall

Summary
Design Report
for the
PeRT Wall at Monticello, Utah

Draft

February 1999

Prepared by
U.S. Department of Energy
Grand Junction Office
Grand Junction, Colorado

Project Number PTW–121–0001–00–000
Document Number K00051AA

Work Performed Under DOE Contract Number DE–AC13–96GJ87335
Task Order Number MAC99–12

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1.0 Introduction

A permeable reactive treatment (PeRT) wall is a zone of reactive material that is placed in a contaminated aquifer such that the ground water is remediated as it passes through the wall. This report presents design considerations for the PeRT wall that will be installed at the Monticello Mill Tailings Site (MMTS). The MMTS is a former uranium and vanadium-processing mill in the city of Monticello, Utah. Because of past milling activities, the ground water below the former Millsite (owned by the U.S. Department of Energy [DOE]) and the land downstream of the former Millsite (privately owned) is contaminated above federal and state standards.

The MMTS is regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). An Interim Record of Decision (IROD) was signed in 1998 that includes the PeRT wall as a partial remedy for Operable Unit (OU) III, which includes contaminated ground water. The IROD stipulates that the performance of the wall will be evaluated over a number of years to determine if it may be a final solution for this site.

The PeRT wall technology demonstration project is being funded under the auspices of the Accelerated Site Technology Development Program from DOE's Office of Science and Technology. The teaming partners on this project are the DOE–Grand Junction Office (DOE–GJO), Sandia National Laboratory (SNL), DOE Western Environmental Technology Office (MSE Technology Applications, Inc. [MSE]) and the University of Waterloo.

2.0 Document Purpose

The purpose of this report is to provide supporting documentation for the design, construction, and performance monitoring of a PeRT wall at the MMTS. Much of the supporting documentation for this project has been prepared and released as separate reports, specification packages, drawings, or memoranda. This document provides an overview of the design, describes the function of the major components, and discusses the major design considerations with reference to the previously developed supporting material.

3.0 Design Overview

A PeRT wall is a passive remediation system that chemically reduces concentrations of contaminants as they pass through a reactive material. Zero-valent iron (ZVI) is the reactive material that will be used because of its ability to remove the contaminants of concern (COCs) from the ground water at the MMTS (see Section 4.4). The primary COCs at this site are arsenic, manganese, selenium, uranium, vanadium, and lead-210. This is a technology demonstration project; however, the wall has been designed to capture as much of the contaminated ground water as possible.

The PeRT wall will consist of permeable gate and impermeable funnel sections. The southern funnel section (approximately 250 feet in length) and northern funnel section (approximately 55 feet in length) will be constructed using impermeable material such as steel sheet piling driven into the underlying bedrock aquitard. The purpose of the impermeable wall is to funnel contaminated ground water in the Montezuma Creek shallow aquifer to the reactive gate. The reactive gate will be constructed by driving steel sheet piling down to bedrock forming a rectangular box approximately 100 feet long by 8 feet wide. The native materials inside the box will be excavated to the bedrock aquitard and replaced with ZVI and gravel.

Gravel packs will be placed on the upstream and downstream side of the iron. The upstream gravel pack will be approximately 2 feet wide composed of 10 percent (by volume) coarse ZVI material mixed uniformly with pea gravel. This upgradient gravel/ZVI layer is more permeable than the main reactive zone. Precipitation products should form mostly in this zone. The chances for long-term clogging are reduced by starting precipitation in this gravel layer (most of the precipitation normally occurs in the first centimeters of a ZVI barrier). The middle 4 feet of the PeRT wall will contain 100 percent ZVI. The downstream gravel pack will be an approximately 2 feet wide layer of pea gravel.

The downstream gravel layer will include an air sparging system constructed of solid and perforated polyvinyl-chloride pipe. Data from the treatability study indicate that iron and manganese may be released from the PeRT wall and become mobile in the ground water. The air sparging system may be used to help precipitate iron and magnesium. The field treatability study showed that active aeration of ground water greatly reduces concentration of iron and manganese in solution. It is anticipated, but has not yet been demonstrated, that the iron and manganese will precipitate out of solution as the treated ground water migrates through the aquifer downgradient of the PeRT wall and will therefore not present a risk. Monitoring of iron and manganese will begin shortly after the PeRT wall is constructed to determine any increases in ground-water concentrations. After reviewing these data, the project team may decide to commence operation of the air sparging system to help limit the migration of iron and manganese.

After the reactive materials and gravel are placed in the excavated box, the sheet pilings perpendicular to the ground-water flow will be removed (two 100-foot sections) to allow ground water to flow through the reactive portion of the wall. The detailed construction specifications are presented in DOE 1998a; the construction drawings are included as Plates 1–4

4.0 Design Considerations

This section presents information on the issues that impact the design. Information is presented on the characterization data, estimation of wall thickness, longevity of the PeRT wall, reaction chemistry, use of the treatability studies and the OU III ground-water modeling in design development, and property owner lease/easements.

4.1 Summary of Characterization Data

A subsurface investigation was conducted in May and June 1998 to support the design and construction phases of the PeRT wall. The objective of this characterization was to determine bedrock depths, water table elevations, subsurface lithology, and uranium concentrations in ground water. Subsurface conditions were investigated at 19 locations using a hydraulically powered direct push/percussion probe rig (Geoprobe® Systems, model 4200). Each probe hole was extended into bedrock and temporary piezometers were installed for water-level measurement and ground-water sample collection.

A test pit was also excavated in May 1998 in the same area to provide lithologic information. The pit was approximately 5 ft wide by 12 ft long and 15 ft deep. The results of this May-June characterization and data from a 1992 characterization effort used to support the OU III Remedial Investigation (RI) are presented in DOE (1998b). This report includes results on (1) the lithology of unconsolidated materials, (2) bedrock lithology, (3) depth to ground water, (4) depth to bedrock, and (5) ground-water flow and ground-water sampling results for uranium.

After this characterization was completed, the proposed location of the reactive gate was moved to the east. This was done to capture and treat more of the plume and to minimize impact on the upcoming remediation of the Pond 3 area, which is immediately upgradient of the PeRT wall location. In addition, because of a change to the north of the alignment of Montezuma Creek, the southern impermeable wall is now proposed to cross the remediated abandoned stream channel and lay in a southwesterly direction. A new round of characterization occurred at the end of January 1999 to more accurately determine the bedrock cross section, ground-water levels, and contaminant concentrations. Attachment A provides a description of this characterization effort. Preliminary results are expected to be available by mid to late February.

4.2 Estimation of Permeable Gate Thickness

The calculation used to estimate the gate thickness is presented in Attachment B. This indicates that a wall less than one-inch thick is needed to account for sufficient residence time to meet PRGs. Additional thickness is needed to increase the longevity of the PeRT wall. A thickness of 4 feet was designed so that the wall will last at least 120 years.

4.3 Longevity of the PeRT Wall

A PeRT wall using ZVI to treat chlorinated organics operated for about 5 years at a site in Canada. The ZVI at this site was observed to be relatively fresh in appearance and clogging from mineral precipitation appeared to be minimal (O'Hannesin and Gillham 1998). One of the purposes of this technology demonstration project is to determine the longevity of ZVI for final use at this and other sites that may benefit from this technology.

Three factors can limit the longevity of a ZVI-based PeRT wall: (1) dissolution of ZVI, (2) surface passivation, and (3) loss of hydraulic conductivity. An estimate of ZVI dissolution (loss) is presented below.

Assuming a flow rate of 50 gpm, 30 mg of ZVI per liter is dissolved (based on laboratory treatability studies) and ZVI density is 190 lbs/ft^3, the 4-foot thick PeRT wall should last 120 years.

$$\frac{year}{5.25\times 10^5\,min}\times\frac{min}{50\,gal}\times\frac{gal}{3.786\,L}\times\frac{L}{30\,mg\,Fe}\times 396\,ton\,Fe\times\frac{9.1\times 10^8\,mg}{ton}=120\,years$$

Surface passivation refers to mineral buildup or other alteration of the ZVI surfaces that will lead to a decrease in the reaction rate. There are no data available with which to evaluate the effects of surface passivation on longevity of the PeRT wall. Some qualitative results from laboratory experiments have suggested that even with thick ferric oxide coatings, ZVI is still able to maintain its reductive capability.

Loss of hydraulic conductivity should occur in the PeRT wall because of the potential for mineral precipitation and possible formation of a free gas phase. Mineral precipitation and gas have been observed in ZVI both in laboratory tests and field projects. At this time, there is no accurate means to evaluate the effect of clogging or longevity. Ground-water major ion chemistry will be monitored to determine the quantity of material that is precipitating in the PeRT wall.

4.4 Reaction Chemistry

All of the contaminants used in this investigation form insoluble phases under reducing conditions. Original investigations of ZVI focused on its ability to reductively dechlorinate chlorinated aliphatic hydrocarbons such as solvents. However, it is also increasingly recognized for its ability to chemically reduce inorganic constituents. The primary COC at the MMTS is uranium. The reaction chemistry for uranium is similar to the chemistry for the other COCs.

Uranium will precipitate as the mineral uraninite (or an amorphous precursor of this mineral) if the oxidation state of an aqueous solution is lowered sufficiently. As an example of this mechanism that could be useful to PeRT walls, consider the precipitation of uraninite by the oxidation of ZVI to ferrous iron in a U-contaminated, carbonate-bearing, near neutral solution:

$$Fe^{\circ}\ (ZVI) + UO_2(CO_3)_2^{2-} + 2H^+ = Fe^{2+} + 2HCO_3^- + UO_2\ (uraninite) \qquad \text{[Reaction 1]}$$

Reductive precipitation reactions are generally slower than sorption reactions and seldom reach equilibrium in ground-water systems. All of the contaminants tested in this study are redox sensitive and it was believed that they would precipitate in the presence of ZVI.

Chemical reduction caused by ZVI affects the entire aqueous system and not just the contaminants; some side effects may need to be considered in designing a PeRT wall. As an example, in Reaction 1, H^+ is consumed which leads to an increase in pH. Increases in pH will lead to precipitation of metal-carbonate or metal-hydroxide minerals that could reduce the permeability of the PeRT wall. The amount of contaminant precipitation due to Reaction 1 is probably small because only trace amounts of U and the other COCs are available even in a contaminated aquifer (these concentrations are still sufficient to cause unacceptable risk using a residential scenario). However, increases in pH can also occur due to other chemical processes, such as the reduction of dissolved oxygen (Reaction 2) or the direct reduction of aqueous protons (Reaction 3):

$$2Fe^{\circ} + 4H^+ + O_2 = 2H_2O + 2Fe^{2+} \qquad \text{[Reaction 2]}$$

$$Fe^{\circ} + 2H^+ = Fe^{2+} + H_2 \qquad \text{[Reaction 3]}$$

Thus, the potential for mineral precipitation due to increasing pH is limited only by the availability of the metals or carbonate and the rates of the reactions. Precipitation of calcite ($CaCO_3$), siderite ($FeCO_3$), and ferrous hydroxide [$Fe(OH)_2$] have been observed in laboratory experiments with ZVI. Generation of hydrogen gas (Reaction 3) has also been observed. Although hydrogen gas is used by some microbes as an electron donor, no detrimental (or positive) effects of hydrogen gas on PeRT walls have yet been confirmed.

4.5 Use of Laboratory and Field Treatability Studies in Design Development

Laboratory and field treatability studies were conducted for this project. The purpose of the laboratory treatability study was to evaluate a variety of reactive materials for their ability to remove COCs from the ground water at the MMTS. Numerous materials were evaluated through a variety of batch and column experiments. The results indicated that ZVI was the most effective in removing the COCs from Monticello ground water. DOE 1998c describes the complete methods and results from these tests.

Field treatability tests were conducted on site using larger columns; site ground water was withdrawn from the contaminated aquifer in the area where the PeRT wall will be emplaced and used in the columns. The purpose of this work was to evaluate the following: (1) removal of contaminants by ZVI from five suppliers, (2) chemical transport in the alluvial aquifer by effluent from a ZVI-containing column, (3) iron and manganese mobilization from ZVI, (4) changes in hydraulic conductivity, (5) concentrations of priority pollutant metals, and (6) rates of contaminant uptake and mineral precipitation.

The field treatability studies showed that the PeRT wall would effectively reduce uranium, arsenic, and selenium using ZVI from any of the suppliers. However, it was found that iron and manganese may be released in solution from the ZVI. Manganese is released because it is typically a trace contaminant on ZVI. Previous experiments have found that concentrations of manganese in solution decrease as the number of pore volumes passing through the ZVI increase. To address potentially elevated concentrations of iron and manganese, the PeRT wall design was modified to include an air sparging system to precipitate iron and manganese from ground water downgradient of the ZVI. The field treatability work included a test of air sparging on water after it passed through ZVI and it was found to greatly reduce iron and manganese concentrations in solution to acceptable levels. A complete description of the methods and results of the field treatability studies is presented in DOE (1998c).

4.6 Use of OU III Modeling in Design Development

Ground-water flow modeling was performed to evaluate capture effectiveness and aquifer response to a variety of funnel and gate-type PeRT system designs. The ground-water flow model developed under the MMTS OU III RI was adopted, with slight modification, as the baseline flow condition used in the evaluation. The modifications to the baseline flow model and the results of the PeRT wall capture simulations were presented in Cromwell 1998. The variables tested in the PeRT models were funnel wall length and orientation north and south of the reactive gate, and the hydraulic conductivity of the reactive gate. The results were used to evaluate the amount of ground water that was captured versus that which bypassed a given system, to evaluate hydraulic head response upgradient of the wall, and to analyze flow downgradient of the gate and wall. These initial modeling results indicated that a 100-foot gate section is adequate to treat the COCs and to avoid excessive mounding of the ground water upgradient of the PeRT wall.

The proposed location of the wall and the alignment of Montezuma Creek in the PeRT area have changed since the initial simulations were conducted. Also, based on the construction sequence, the option exists to adjust the position of the reactive gate. Additional modeling was therefore conducted to evaluate the effects of the proposed changes and options. A second baseline flow model was developed in which Montezuma Creek was represented in its proposed post-remediation alignment and elevation on the Millsite and in the area of the PeRT wall. Riverbed conductance terms (MODFLOW River Package) were preserved from the original baseline model. Three PeRT simulations were conducted using the revised baseline model, in which the north-south position of the reactive gate was varied, and the location of the entire system was shifted approximately 150 ft east from previous position (see Table 4.6–1).

Table 4.6–1. Summary of Additional PeRT Flow Models

Model	Gate [1]		Funnel [1]		Other
	Length [ft]	Conductivity [cm/sec]	Length North of Gate [ft]	Length South of Gate [ft]	
PERT7	N/A: revised baseline flow conditions with new creek alignment				
PERT7A	100	3E-02	200	250	PERT7 with funnel and gate, gate between old and new creek
PERT7B	100	3E-02	350	150	PERT7 with funnel and gate, gate south of old creek alignment
PERT7C	100	3E-02	300	150	Same as PERT7B but wall and gate 150 ft east

[1] All gate sections are 10 ft wide parallel to ground-water flow. All funnel hydraulic conductivity and widths are 3.5E–09 cm/sec and 10 ft, respectively.

Capture effectiveness and flux through the reactive gate for the recent models are summarized in Table 4.6–2. Each model resulted in total capture of ground water flowing through the alluvial valley in the PeRT area. Shortening the length of the north and south funnel walls from the dimensions listed in Table 4.6–1 resulted in progressively increasing the amount of bypass. However, the length of the north wall required for total capture in the models may be greater than needed. This is because the aquifer is represented in the model as a continuous unit to the north of the PeRT system, whereas field data indicates that the bedrock surface rises steeply in that area and saturated alluvium is absent. Similarly, the southern boundary of the aquifer in the alluvial valley is not precisely known. Field characterization done in late January 1999 investigated subsurface conditions in those areas. Once results are available, this will help determine the final length of wall. Figures depicting the model configurations and results are included in Attachment C.

Table 4.6–2. Summary of Additional PeRT Model Capture Analysis

Model	Flux through Gate [gpm]	Contaminated Ground water Bypass North of Gate [gpm]	Contaminated Ground water Bypass South of Gate [gpm]
PERT7	15 (approx.)	not estimated	not estimated
PERT7A	44	Nil	Nil
PERT7B	40	Nil	Nil
PERT7C	40	Nil	Nil

The revised baseline flow model (PERT7) predicts that the realigned reach of Montezuma Creek in the immediate area upgradient of the PeRT wall will be a net losing stream. The amount of stream loss was approximately one-tenth of typical stream flows (0.5 ft^3/sec). In the previous baseline model the existing creek was gaining in that area. As a result of the predicted stream loss (PERT7), local ground-water levels were 1 to 2 feet higher relative to the previous baseline model. In the remaining simulations (PERT7A to PERT7C) the exchange between the creek and aquifer was negligible. In the reach east of the PeRT area, the stream is gaining in the baseline and PeRT models.

Ground-water elevations were predicted to increase between approximately 2 and 3 ft in the upgradient area near the PeRT walls, relative to the baseline model, which is consistent with the previously reported modeling results. There was no instance of cell flooding (i.e., predicted head > ground surface) in any of the models. Ground water was predicted to be a minimum of about 4 feet below the existing grade in the PeRT models. The modeling results served as input for the final elevation of Montezuma Creek on the restored property adjacent to and upgradient of the wall. The top of the gate and walls are expected to be 0.5 foot below the intermediate grade (before final backfill is added).

Ground-water travel paths and total flow quantity in the PeRT area were not significantly affected by the new creek alignment and elevation. For example, fluxes through the reactive gate using the PERT7 baseline model were 40 and 44 gallons per minute (gpm). These values represent total capture of ground-water flow in the alluvial valley. In the previously submitted models, total flow and capture was about 46 gpm. The slight discrepancy arises from increased aquifer discharge to the stream in response to the lower stream elevations on the Millsite in the PERT7 model. A portion of the ground water exiting the gate initially flows north and south to occupy the immediate area east of the impermeable wall sections. Baseline flow paths and hydraulic heads are then restored within a short distance down gradient of the PeRT system (see Attachment C).

4.7 Property Owner Lease/Easement Arrangement

The PeRT wall will be placed on private property east of Pond 3 (Property MP-00179). A lease arrangement has been made with that property owner to construct the PeRT wall on the property and continue site access through June 2003.

DOE is also negotiating with that property owner for a 40-year easement. This would allow the PeRT wall to continue operating if it is included as part of the final ROD for OU III. The easement should be finalized in early 1999.

4.8 Construction Considerations

This section focuses on the following three issues that will be encountered during the construction of the PeRT wall: keying of the impermeable walls into bedrock, management of materials encountered during excavation, and realigned stream impacts on the PeRT wall.

4.8.1 Keying of Impermeable Walls Into Bedrock

The sheet piling for the PeRT wall will be driven two feet into the underlying bedrock aquitard to create an impermeable seal. This will ensure that the ground water at the impermeable walls is funneled to the reactive gate. In addition when the reactive portion of the wall is constructed, the impermeable seal created by driving the sheet piling two feet into the underlying bedrock aquitard will enable the soils to be completely excavated from the box. This will allow the ZVI treatment media and gravel packs to contact the bedrock aquitard.

Vibratory equipment will be used to drive the sheet piling. The drier surface material will be penetrated with little effort. As the sheet pile encounters the alluvial aquifer it will almost move through it to the bedrock aquitard under the weight of the driving equipment. When the bedrock aquitard is encountered, the vibratory driving equipment will be required to penetrate it. As the sheet piling is driven deeper into the bedrock aquitard, the rate of penetration will slow. The elevation where the bedrock aquitard is encountered will be recorded and monitored to assure that the required depth is reached. Alignment will be constantly checked to ensure that pilings are placed plumb and that required tolerances are not exceeded. In addition, the bedrock depths determined in the 1998 and 1999 characterization activities will be used to confirm the location of the bedrock.

4.8.2 Management of Materials During Excavation

The reactive gate for the PeRT wall will be constructed by building a sheet pile box, excavating the native materials in the box, and filling the excavated box with gravel and ZVI. The upper portion of the excavation materials are expected to be relatively dry soils while saturated and free flowing material is anticipated within the lower excavation (i.e., the aquifer). In addition, after all the water and material are removed from the box, some ground water will leak into the excavated box before the ZVI and gravel and placed.

The relatively dry soil will be stockpiled near the excavation. Since this is verified clean soil, this material may be used as backfill within the MMTS. In addition, some of the material will be used to cover the completed reactive gate.

A shallow-excavated bermed area to the east of the PeRT wall will be used to contain the free flowing/saturated excavation material. The bermed area is being used to prevent this material from spreading, which would make construction activities difficult. This material will likely be covered with backfill when the final grade for the site is established.

The ground water that leaks into the box after the native materials are excavated but before the gravel and ZVI are placed, will be pumped to Pond 3.

4.8.3 Realigned Stream Impacts on the PeRT Wall

The final orientation of the Montezuma Creek will be north of the current channel. The new alignment will pass over the northern impermeable wall in a 100-foot arched culvert. The culvert will be placed on top of the sheet piling. The bottom of the culvert over the northern impermeable wall will be at an elevation of 6,791.5 feet. The stream will enter the culvert at an elevation of 6,792.2 feet and exit the culvert at an elevation of 6,790.5 feet. The culvert will pass through a notch in the sheet piling. The height of the sheet piling is 6,793.5 feet except for the notch, which is at 6,791.5 feet. After the culvert is placed, the notch will be sealed up to 6,793.5 feet. Attachment D shows the preliminary Montezuma Creek alignment.

For most of the year, the stream channel immediately upgradient of the PeRT wall is expected to drain into the ground water. However, during spring runoff, ground water is expected to rise into the realigned Montezuma stream channel upstream of the culvert. Portions of Montezuma Creek upstream of the PeRT wall (the western portion of MP–00179 and on the Millsite) are anticipated to have ground-water infiltration throughout much of the year. The estimates of the relationship between the ground water and the realigned Montezuma Creek were based on the modified Operable Unit III ground-water model.

The elevation of the culvert was selected to minimize the amount of ground-water infiltration immediately upgradient of the PeRT wall while not requiring excessive amounts of backfill to raise the creek elevation from the Millsite down to MP–00179. This elevation also addresses Kedric Somerville's concerns about the final restoration of his property. The final grade of the property will have 3.5 feet of backfill above the PeRT wall and will be at an elevation of 6,797 feet.

5.0 Monitoring Network

A comprehensive monitoring network is planned to evaluate the performance of the PeRT wall. Figure 5–1 presents a plan view of the proposed monitoring network. DOE 1998d provides details on the network including the monitoring well network location rational and monitoring well network construction details. The monitoring well network will be put in after construction on the PeRT wall is complete.

A separate sampling and analysis plan is being prepared that will describe the sampling frequencies and analysis techniques. This will be complete in early 1999.

6.0 References

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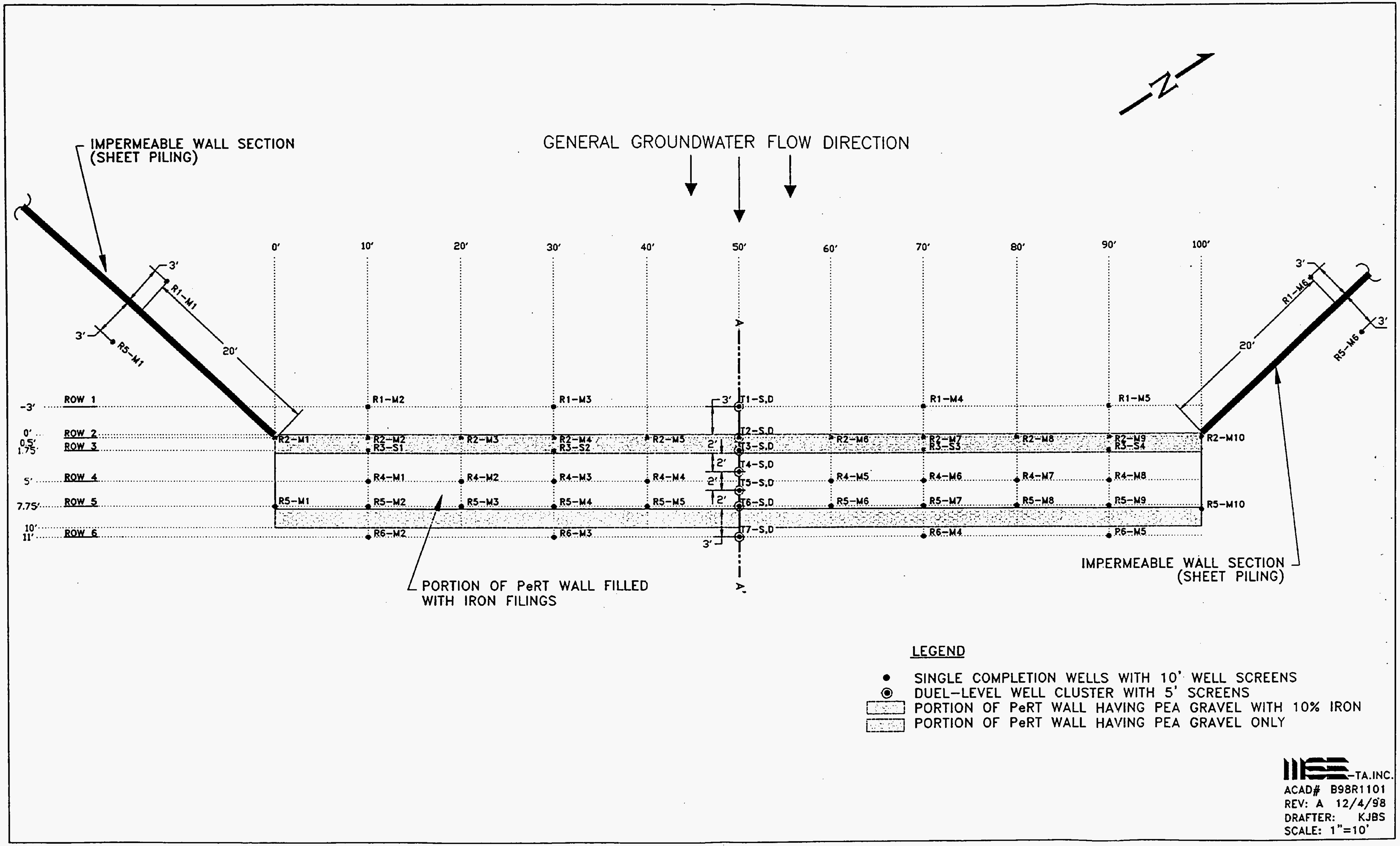

Figure 5–1. Monitoring Well Network for PeRT Wall Performance Monitoring and Tracer Testing

Appendix A

Attachment A

Characterization Plan for the Monticello PeRT Wall Project
December 28, 1998

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CHARACTERIZATION PLAN FOR MONTICELLO PeRT WALL PROJECT
December 28, 1998

Characterization Objectives

Subsurface information will be obtained in the area of the proposed PeRT wall to more precisely delineate: (1) the direction of ground water flow in the alluvial aquifer, (2) the topography of the bedrock surface, (3) the lithology of the alluvial deposits, (4) the distribution of uranium in ground water, and (5) the nature of the upper bedrock. The information is intended to support design and construction issues for the PeRT wall, and will complement subsurface data obtained for the PeRT project in June and July 1998. Emphasis will be placed on characterizing the area of the proposed southern-most extension of the funnel wall (see Figure 1), where the extent of saturated alluvium, uranium distribution in ground water, and bedrock features are not well known. Subsurface conditions will also be investigated along the entire footprint of the proposed PeRT wall, which has changed since the June and July field work was completed.

Scope of Work

A Geoprobe rig will be used to investigate subsurface conditions at 12 to 15 locations (see Figure 1). The locations will be laid out in the field by scaled measurement from Figure 1. Actual hole locations may vary at the discretion of the field supervisor based on field conditions. All work will be conducted following the procedures and methods described in the PeRT Wall Characterization Report (September 1998), which detailed data collection activities, methods, and results of the characterization work conducted in June and July 1998.

A Geoprobe operates by driving small diameter (1 inch) steel rods and sampling tool into the ground. Cores can be retrieved and ground water piezometers can be installed by this technique. At each location, a 2-ft core barrel will be driven until refusal in bedrock. Cores will be collected at depth and examined for lithology. Continuous coring will be done initially to determine the depths of major lithologic changes and to determine the target depth of the bedrock surface along a given segment of the wall. Less frequent sampling (e.g., alternating 2-ft intervals) may then be conducted at the discretion of the field supervisor. The alluvium/bedrock contact will be cored and sampled at each location. Continuous coring of the bedrock will occur until refusal.

Temporary piezometers will be installed at each location. The piezometers will consist of 5-ft sections of 1-in PVC riser and screens. The screen will be placed across the lower 5-ft of the alluvial aquifer. Coarse silica sand will be used to backfill the piezometers to within 6-in of ground surface. The remaining 6-in will be sealed using powdered or granular bentonite. All locations will be surveyed for location and elevation after the piezometers are completed. Water levels will be periodically measured in each piezometer until construction of the PeRT wall. Water levels will also be measured in other pre-existing piezometers and monitoring wells in the PeRT wall area. Water samples will be collected on one or two occasions and analyzed for uranium at the Grand Junction Office Environmental Sciences Laboratory. At least one well casing volume will be evacuated prior to ground water sample collection. Subsurface characterization work will be occur in January or February 1999 depending on weather and site conditions.

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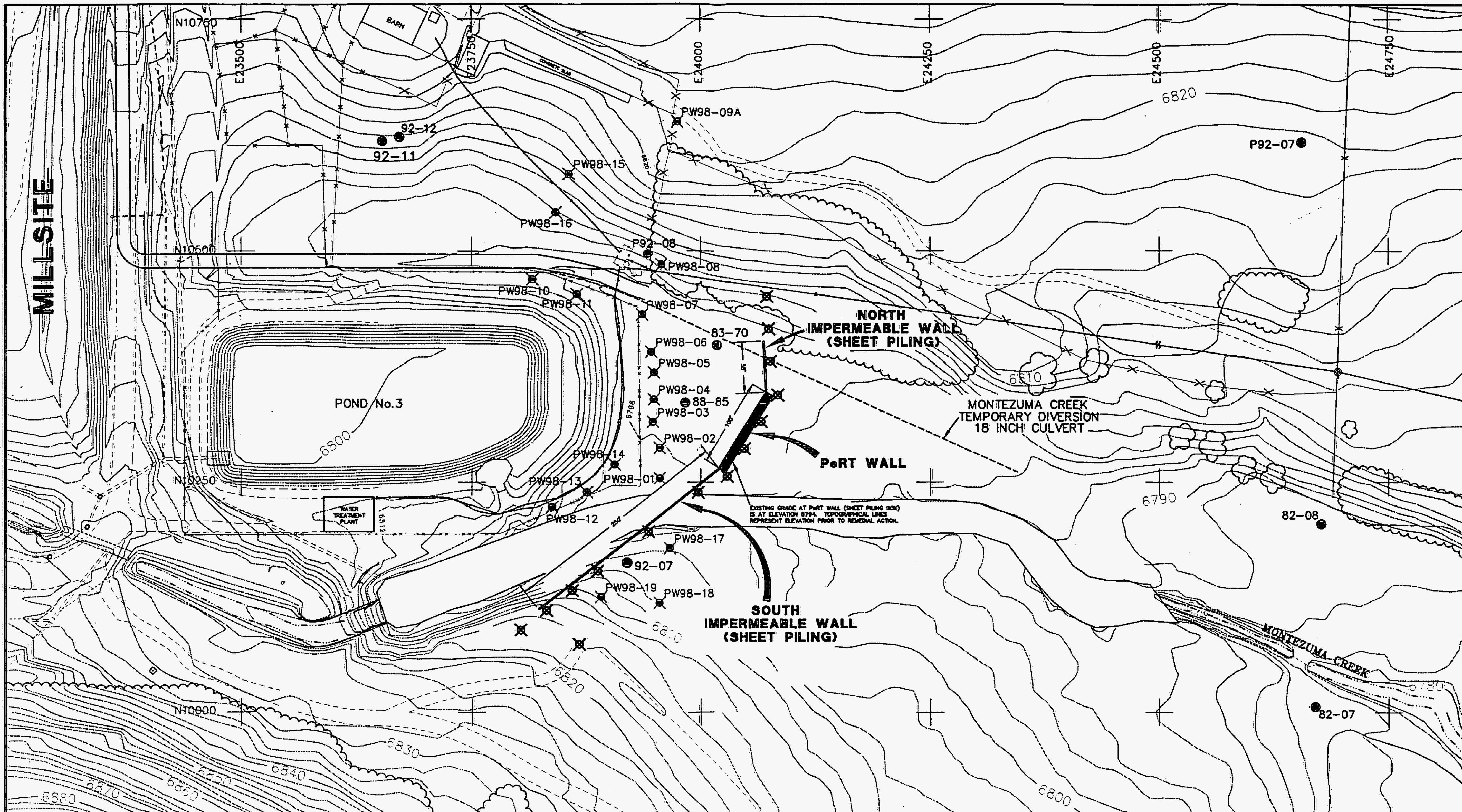

LEGEND

TREE/BRUSH

88-85 EXISTING WELLS

PROPOSED ADDITIONAL TEMPORARY PIEZOMETER LOCATIONS

PW98-01 TEMPORARY PIEZOMETERS INSTALLED JUNE 1998

FENCE

N

SCALE IN FEET
50 25 0 50 100 150

CONTOUR INTERVAL = 2 FEET

M:\PTW\121\0001\K00050AA.DWG 12/22/98 09:52am M50236

macTec-ers

U.S. DEPARTMENT OF ENERGY
GRAND JUNCTION OFFICE, COLORADO

MONTICELLO, UTAH

APPROVALS

PeRT WALL

ADDTIONAL CHARACTERIZATION LOCATIONS, PROPOSED

PTW-121-0001-00-000

K00050AA

1 OF 1

Appendix B

Attachment B

Calculation of Wall Thickness

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Modeling indicates that about 50 gpm flow through the aquifer. The proposed wall is 100 ft long and has a saturated height of 10 ft (1,000 ft^2).

$$50\frac{gal}{min}\times\frac{60\,min}{hr}\times\frac{ft^3}{7.48\ gal}\cong 400\,ft^3/hr$$

$$1{,}000\,ft^2\times\frac{hr}{400\,ft^3}=2.50\frac{hr}{ft}$$

$$2.50\frac{hr}{ft}\times 4\,ft = 10\,hr \text{ (residence time for the 4 feet of 100\% ZVI)}$$

Required residence time based on field treatability study is <6 minutes. Assuming 6 minutes, the "safety factor" is:

$$\frac{10\,hr}{60\text{ min}}\times\frac{50\text{ min}}{hr}=100$$

This accounts for wall degradation through loss of Fe, surface passivation, preferential flowpaths, increased flow (golf course), enhanced remediation (siphoning hot spots), etc.

It also provides a system that is relatively easy to install and monitor (a very thin wall is subject to difficulties in monitoring due to non-vertical wells and concerns about drawing adequate ground water from within the wall).

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Appendix C

Attachment C

Modeling Results

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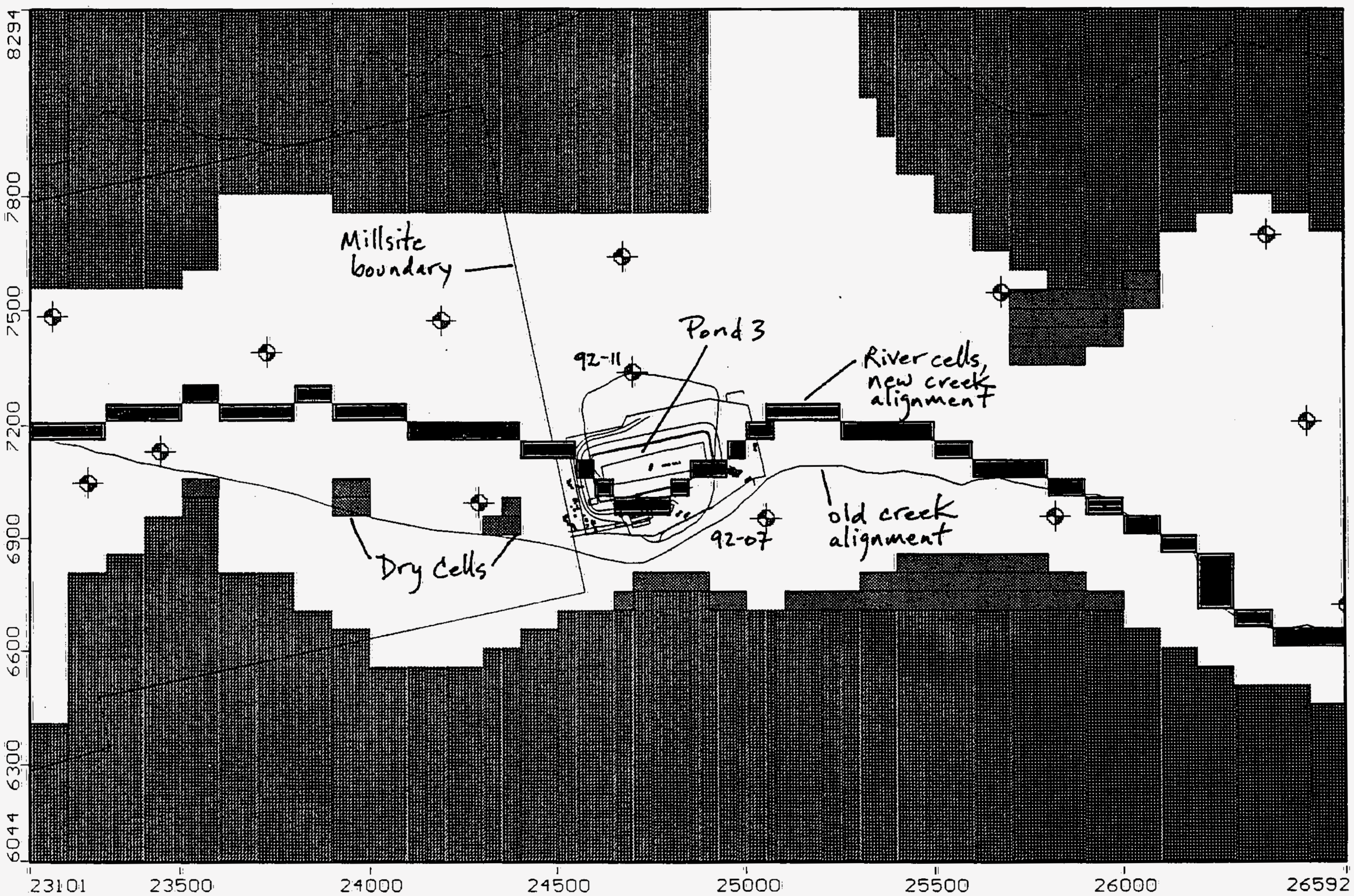
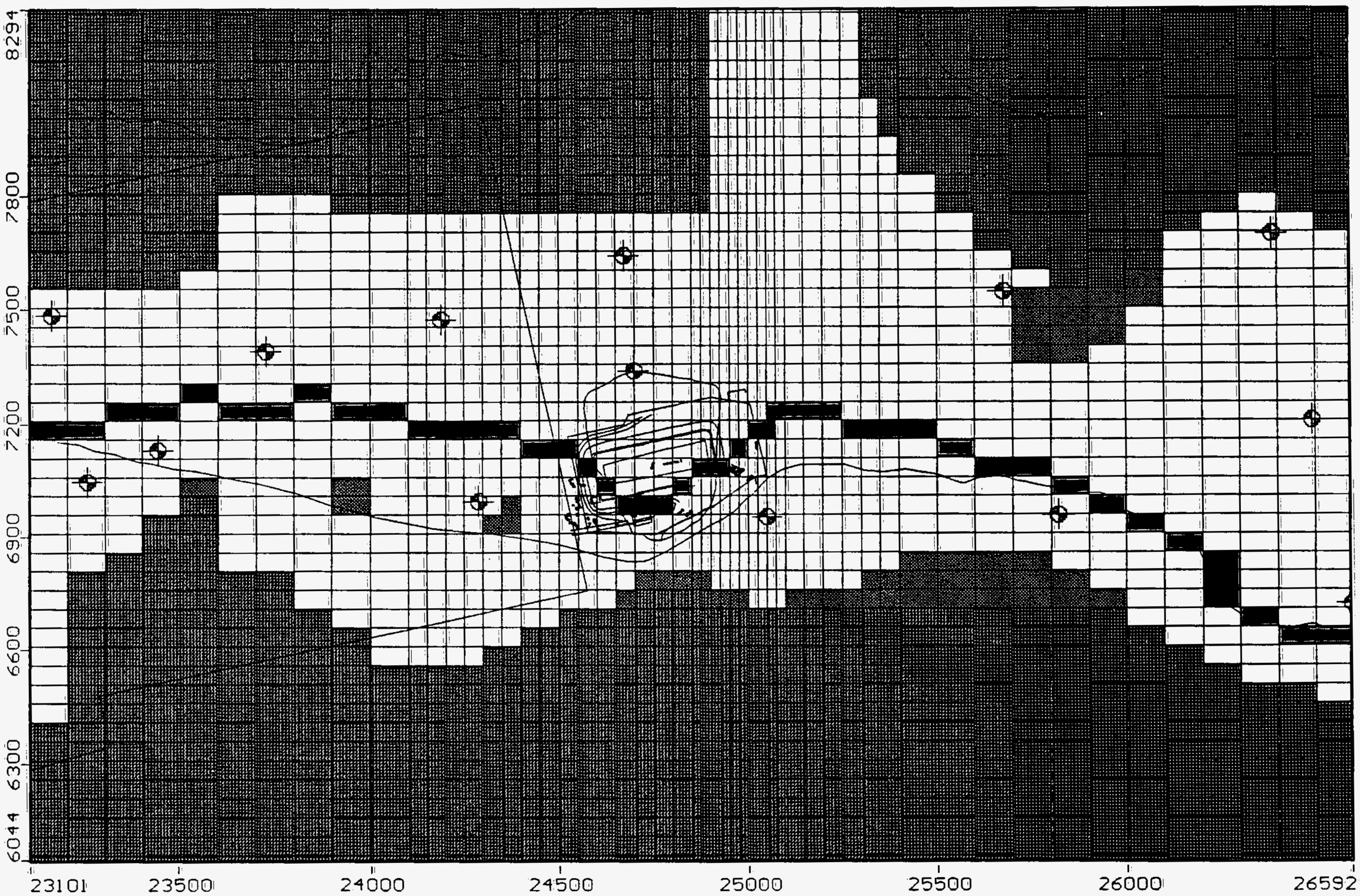


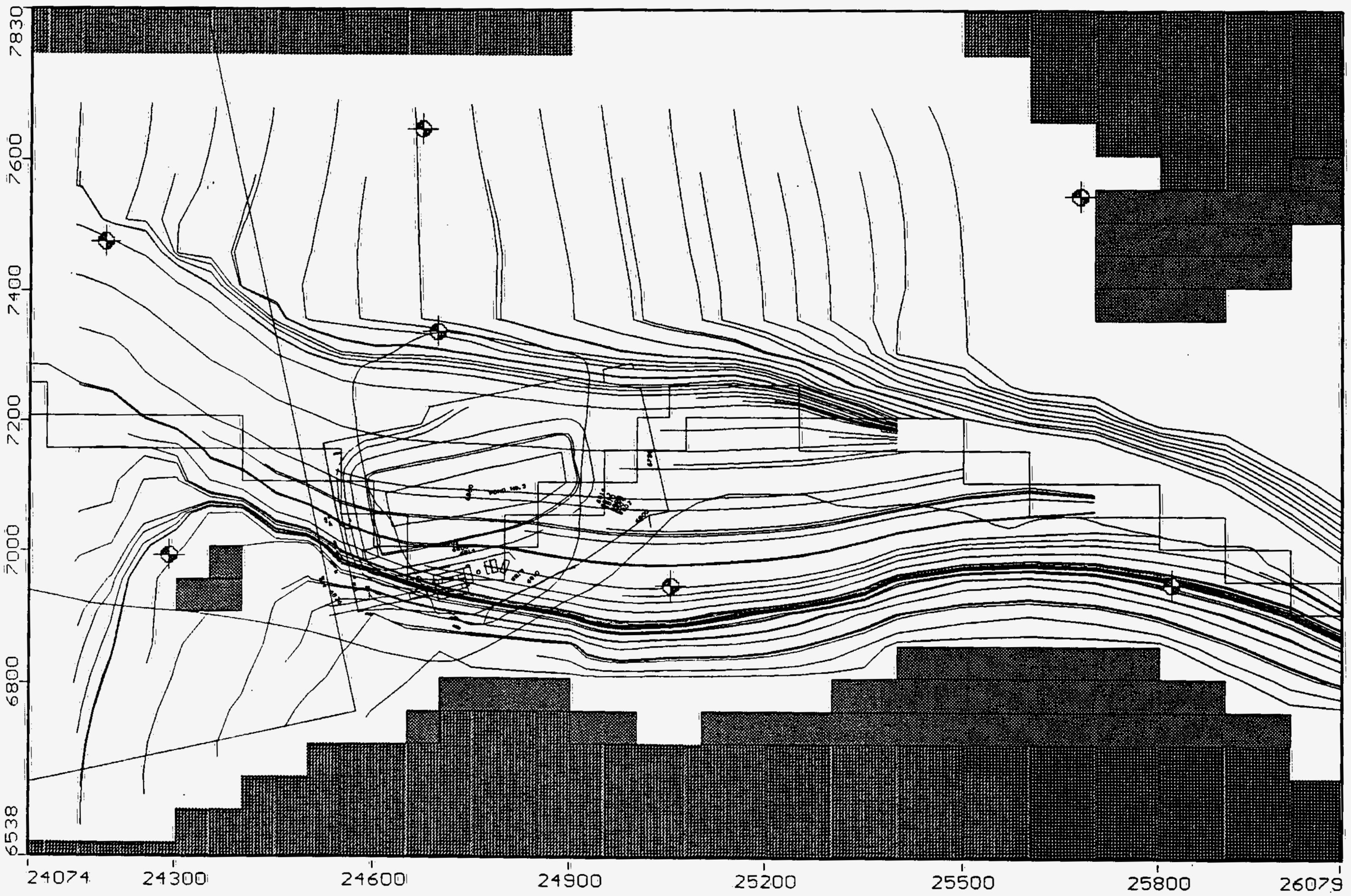
Mactec Project: Monticello PeRT Description: Site features Modeller: MACTEC 5 Jan 99	Visual MODFLOW v.2.7.2, (C) 1995–1997 Waterloo Hydrogeologic, Inc. NC: 226 NR: 78 NL: 1 Current Layer: 1



Mactec
Project: Monticello PeRT
Description: Grid
Modeller: MACTEC
5 Jan 99

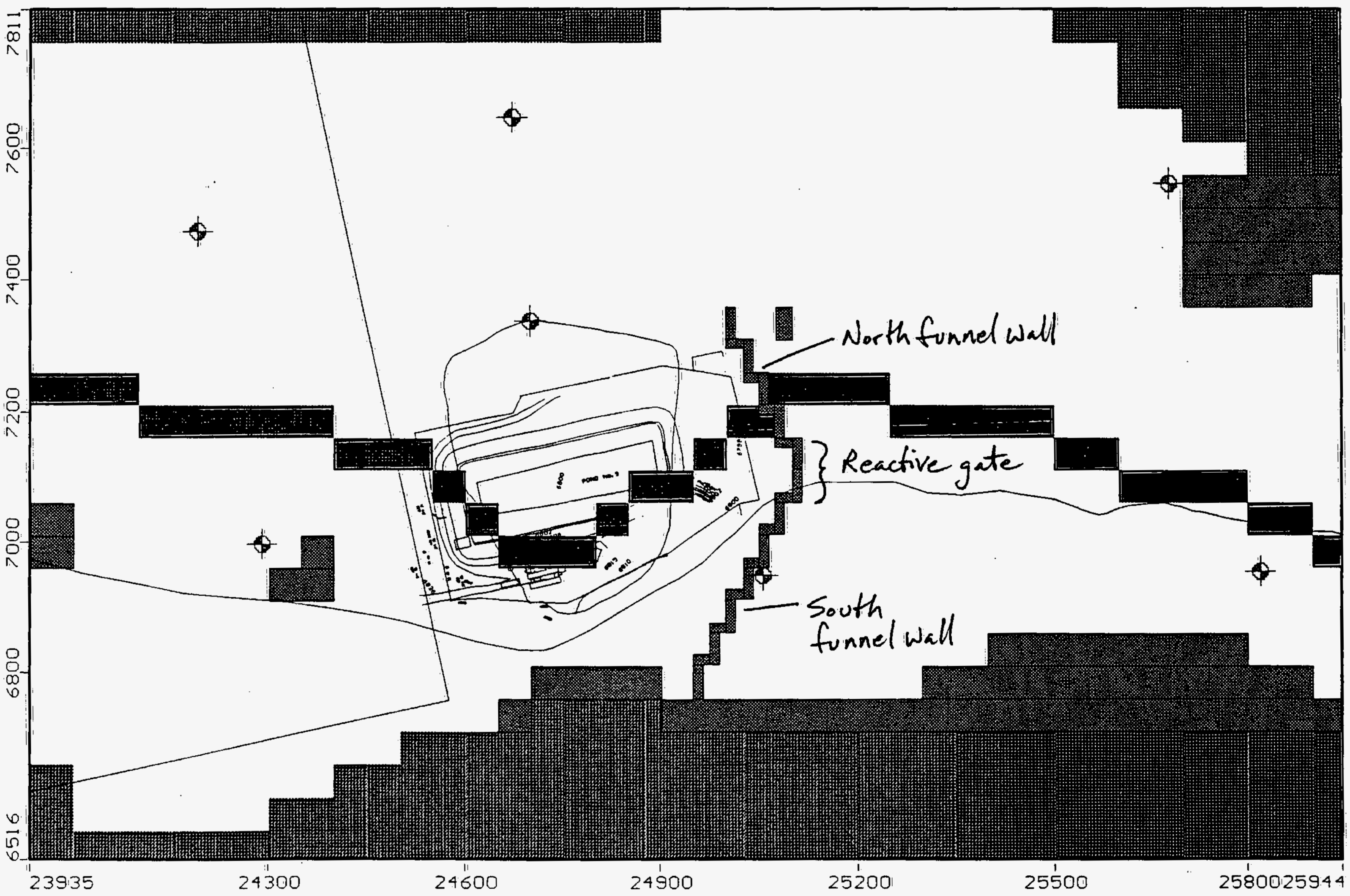
Visual MODFLOW v.2.7.2, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 226 NR: 78 NL: 1
Current Layer: 1

Mactec Project: Monticello PeRT Description: PERT7 heads [ft] Modeller: MACTEC 5 Jan 99	Visual MODFLOW v.2.7.2. (C) 1995-1997 Waterloo Hydrogeologic, Inc. NC: 226 NR: 78 NL: 1 Current Layer: 1

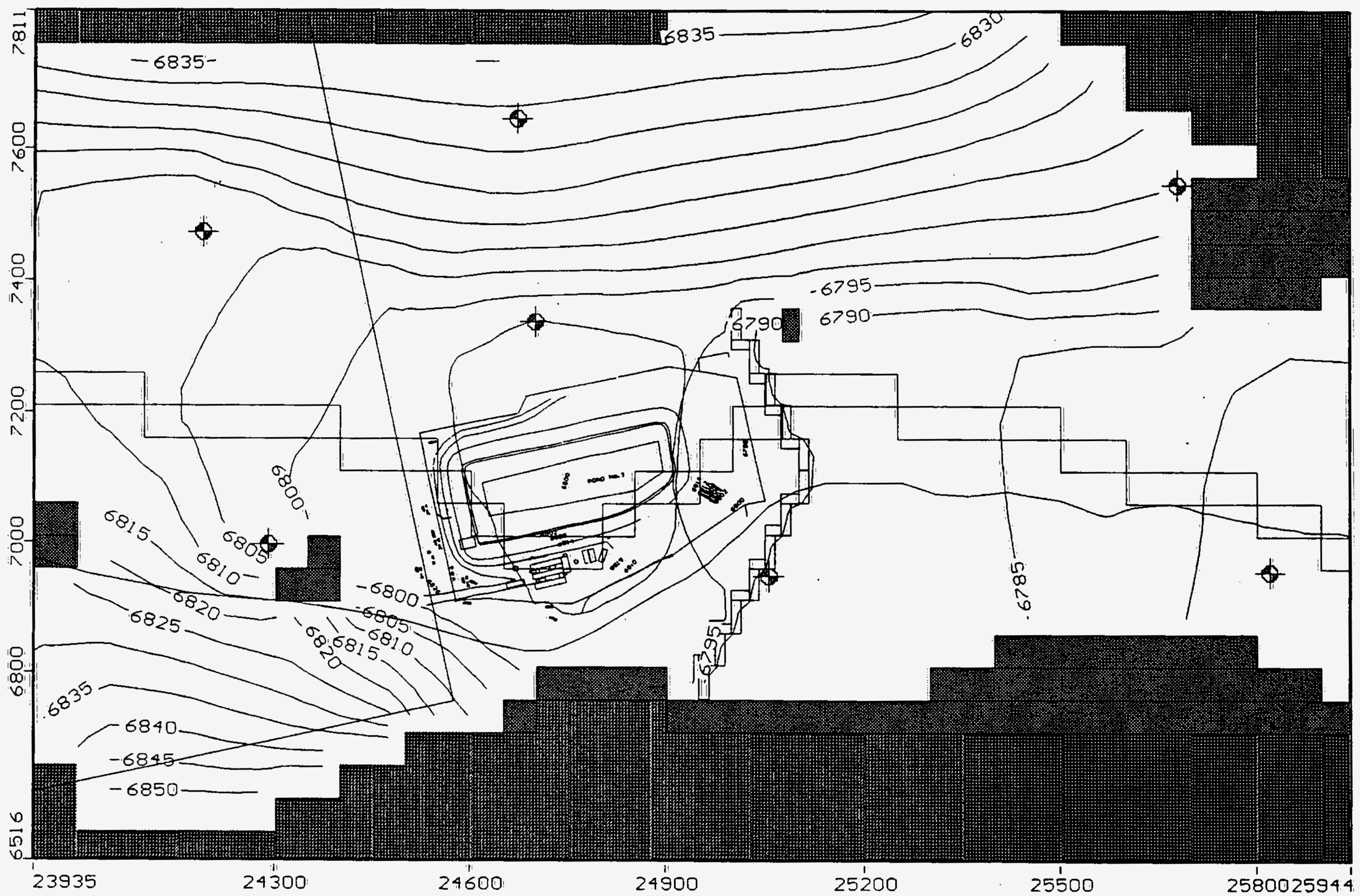


Mactec
Project: Monticello PeRT
Description: PERT7 paths
Modeller: MACTEC
5 Jan 99

Visual MODFLOW v.2.7.2, (C) 1995-1997
Waterloo Hydrogeologic, Inc.
NC: 226 NR: 78 NL: 1
Current Layer: 1

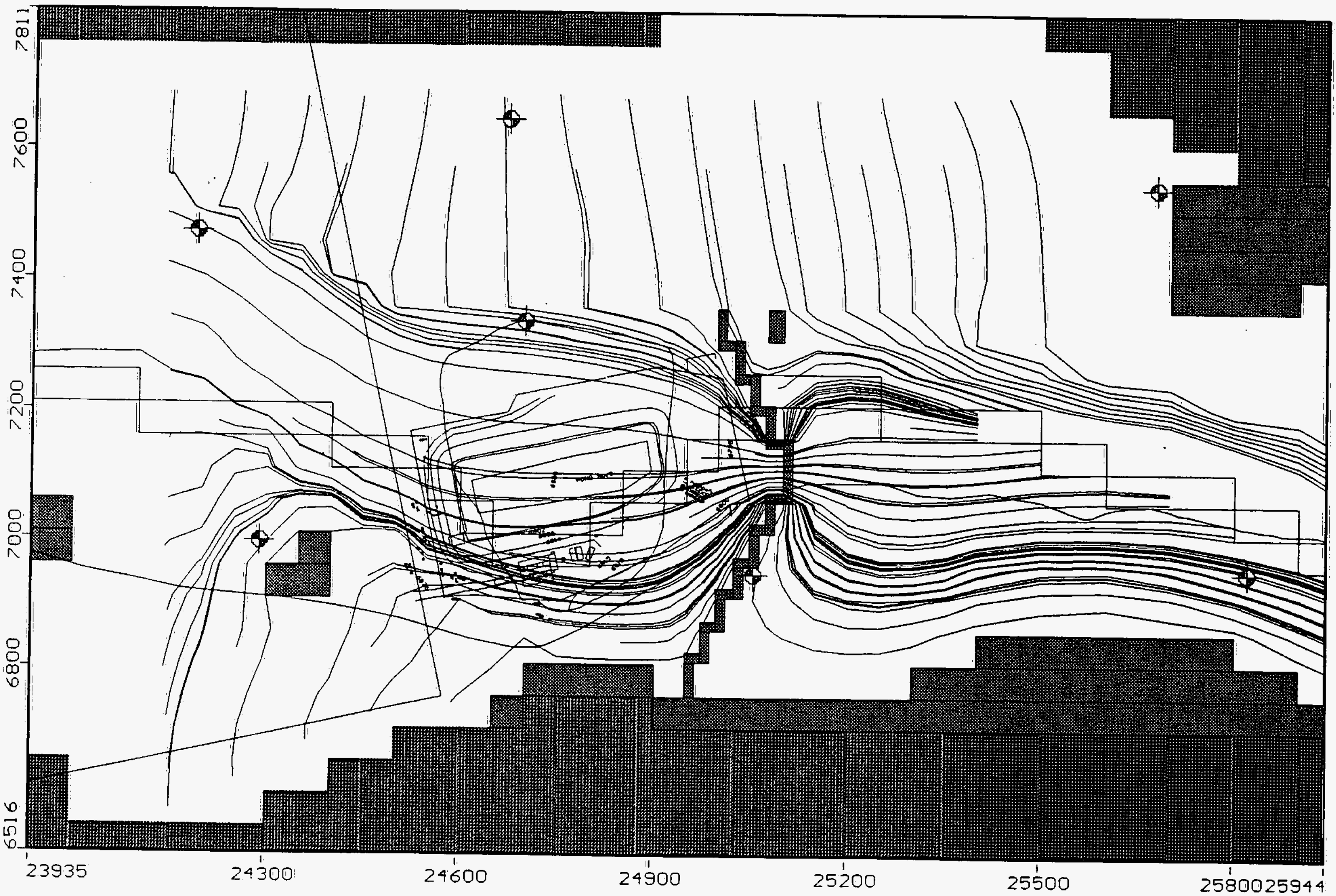


Mactec Project: Monticello PeRT Description: PERT7A wall location Modeller: MACTEC 5 Jan 99	Visual MODFLOW v.2.7.2, (C) 1995-1997 Waterloo Hydrogeologic, Inc. NC: 226 NR: 78 NL: 1 Current Layer: 1



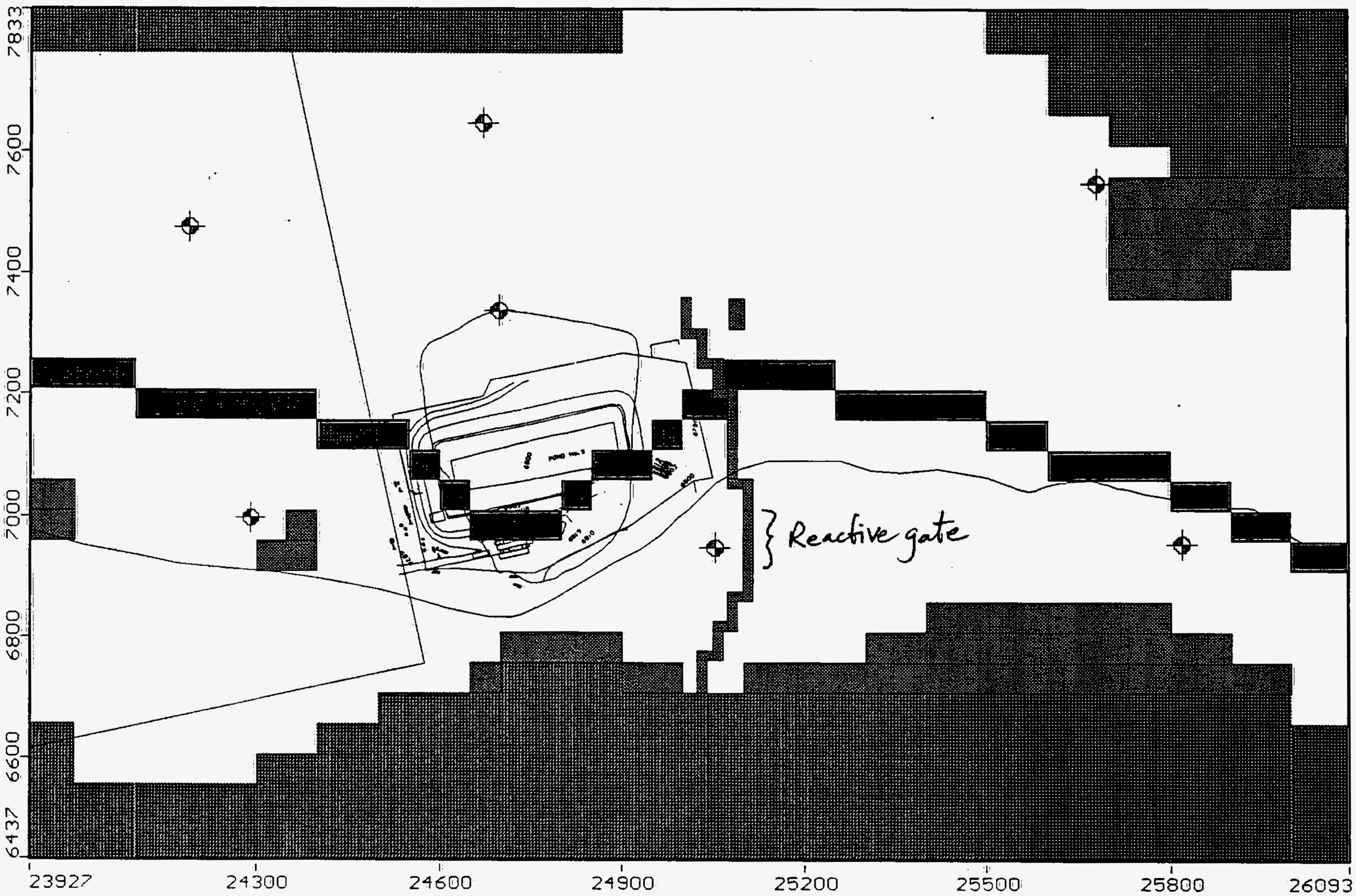
Mactec
Project: Monticello PeRT
Description: PERT7A heads
Modeller: MACTEC
5 Jan 99

Visual MODFLOW v.2.7.2. (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 226 NR: 78 NL: 1
Current Layer: 1



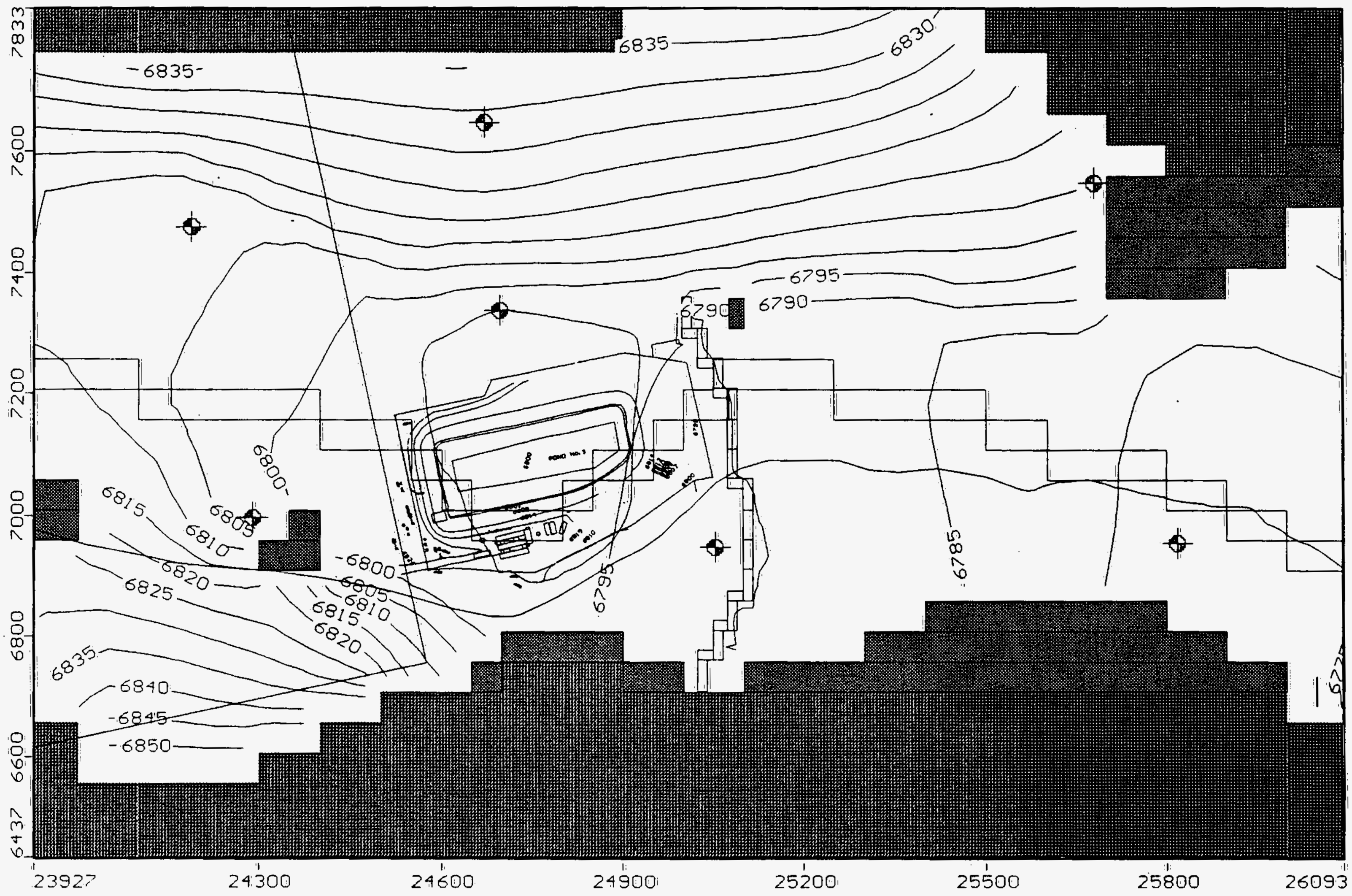
Mactec
Project: Monticello PeRT
Description: PERT7A paths
Modeller: MACTEC
5 Jan 99

Visual MODFLOW v.2.7.2, (C) 1995-1997
Waterloo Hydrogeologic, Inc.
NC: 226 NR: 78 NL: 1
Current Layer: 1



Mactec
Project: Monticello PeRT
Description: PERT7B wall loaction
Modeller: MACTEC
5 Jan 99

Visual MODFLOW v.2.7.2, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 226 NR: 78 NL: 1
Current Layer: 1



Mactec
Project: Monticello PeRT
Description: PERT7B heads (ft)
Modeller: MACTEC
5 Jan 99

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Waterloo Hydrogeologic, Inc.
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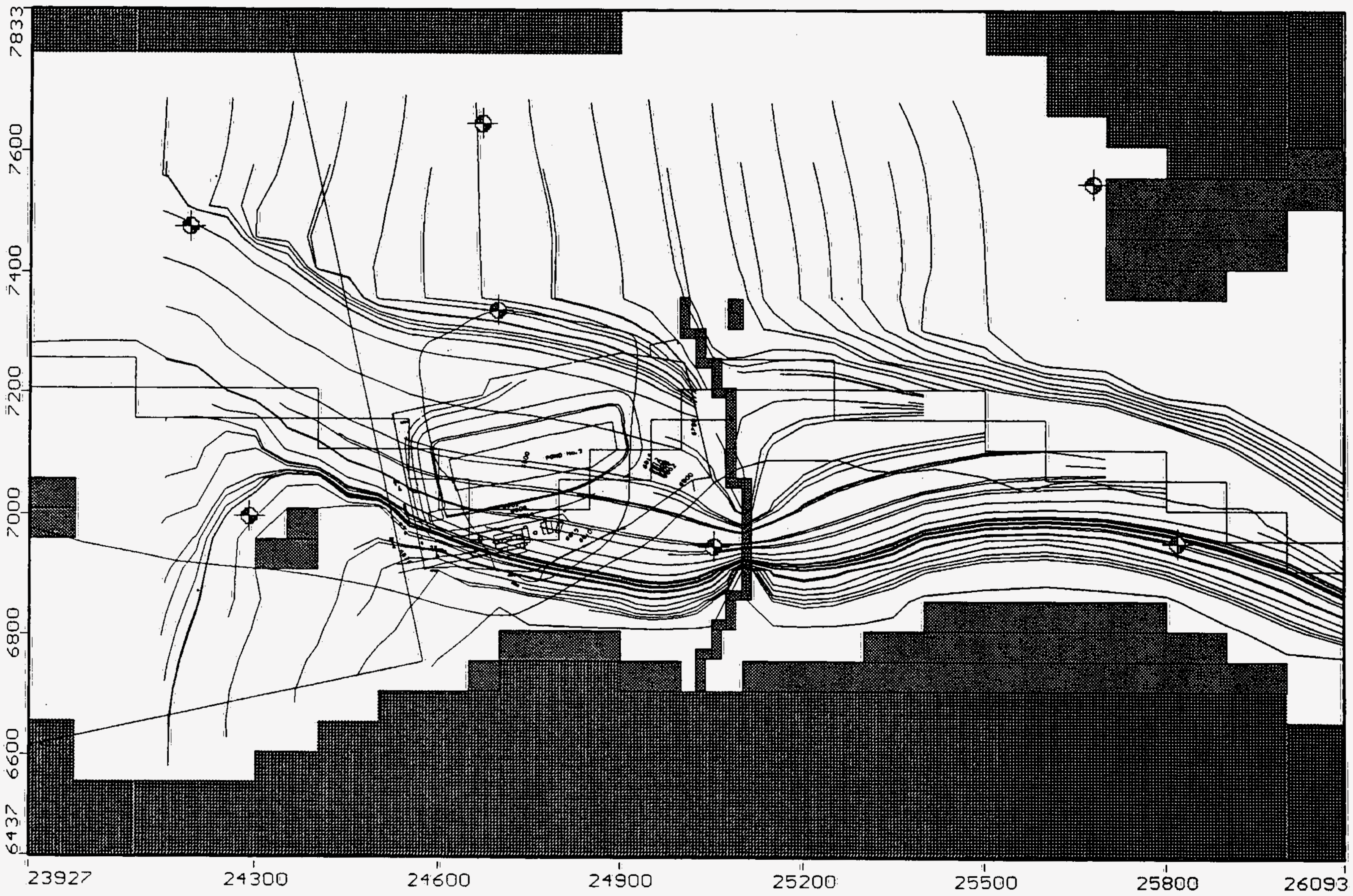
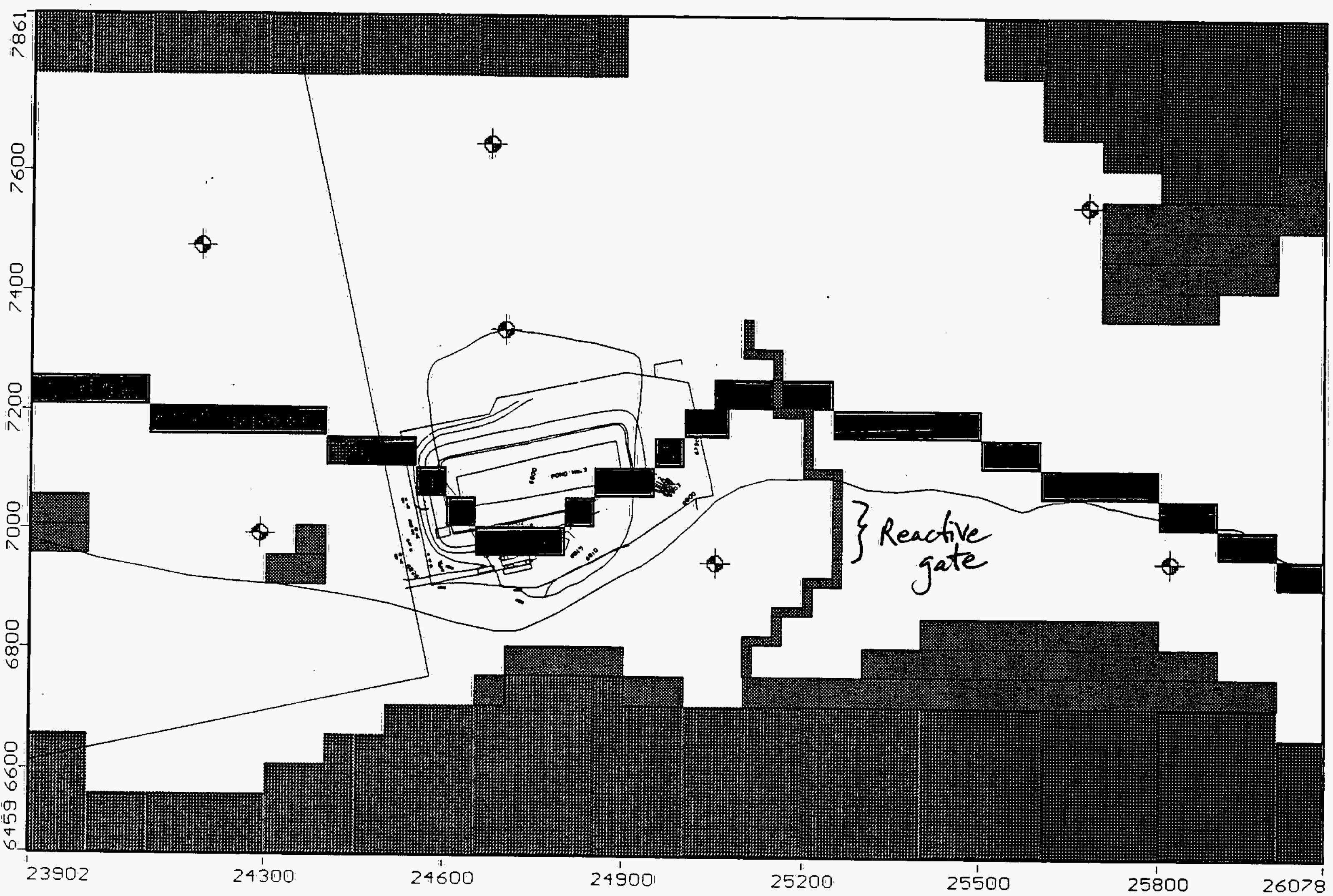
Current Layer: 1



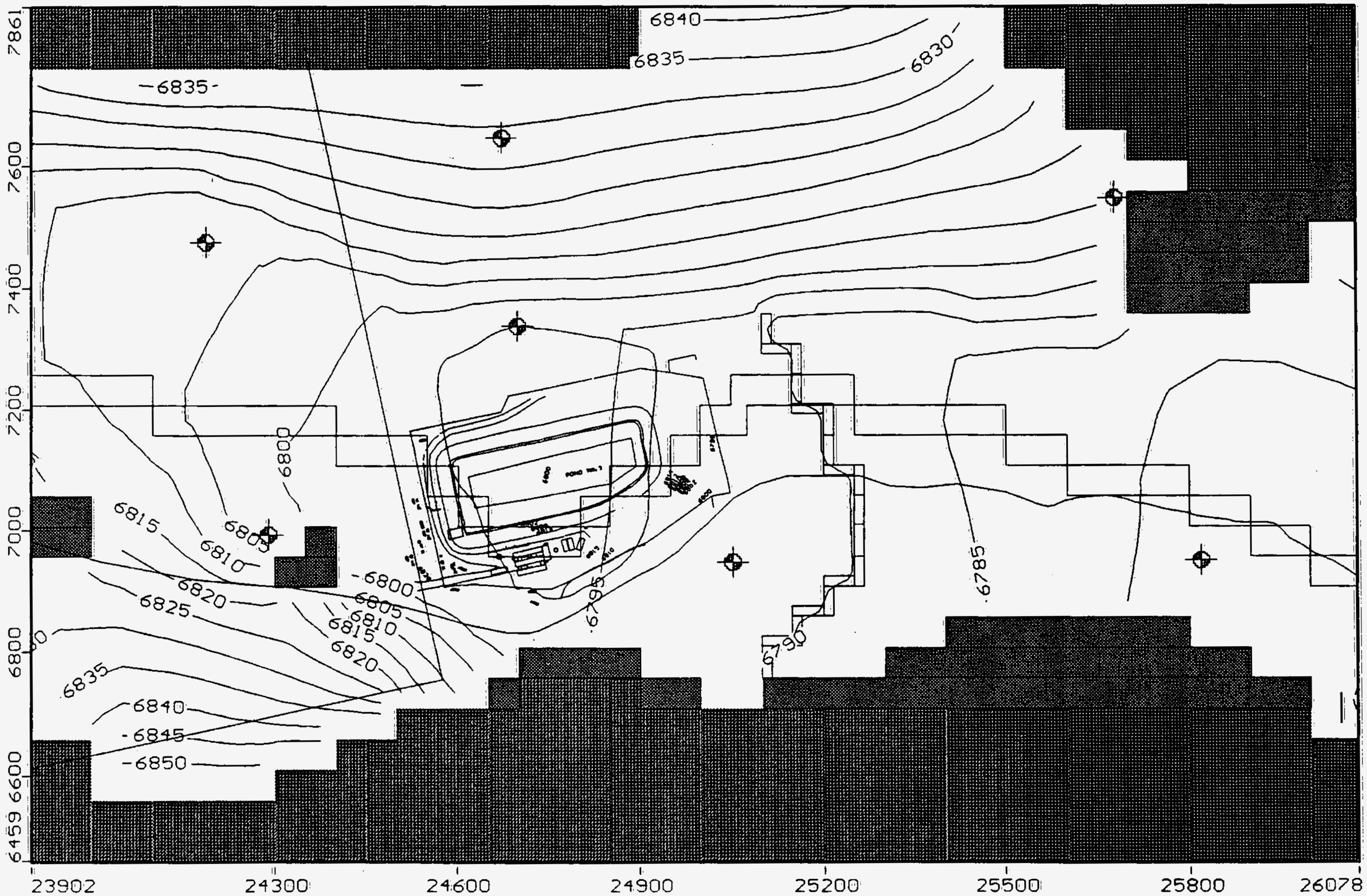
Mactec
Project: Monticello PeRT
Description: PERT7B paths
Modeller: MACTEC
5 Jan 99

Visual MODFLOW v.2.7.2. (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 226 NR: 78 NL: 1
Current Layer: 1



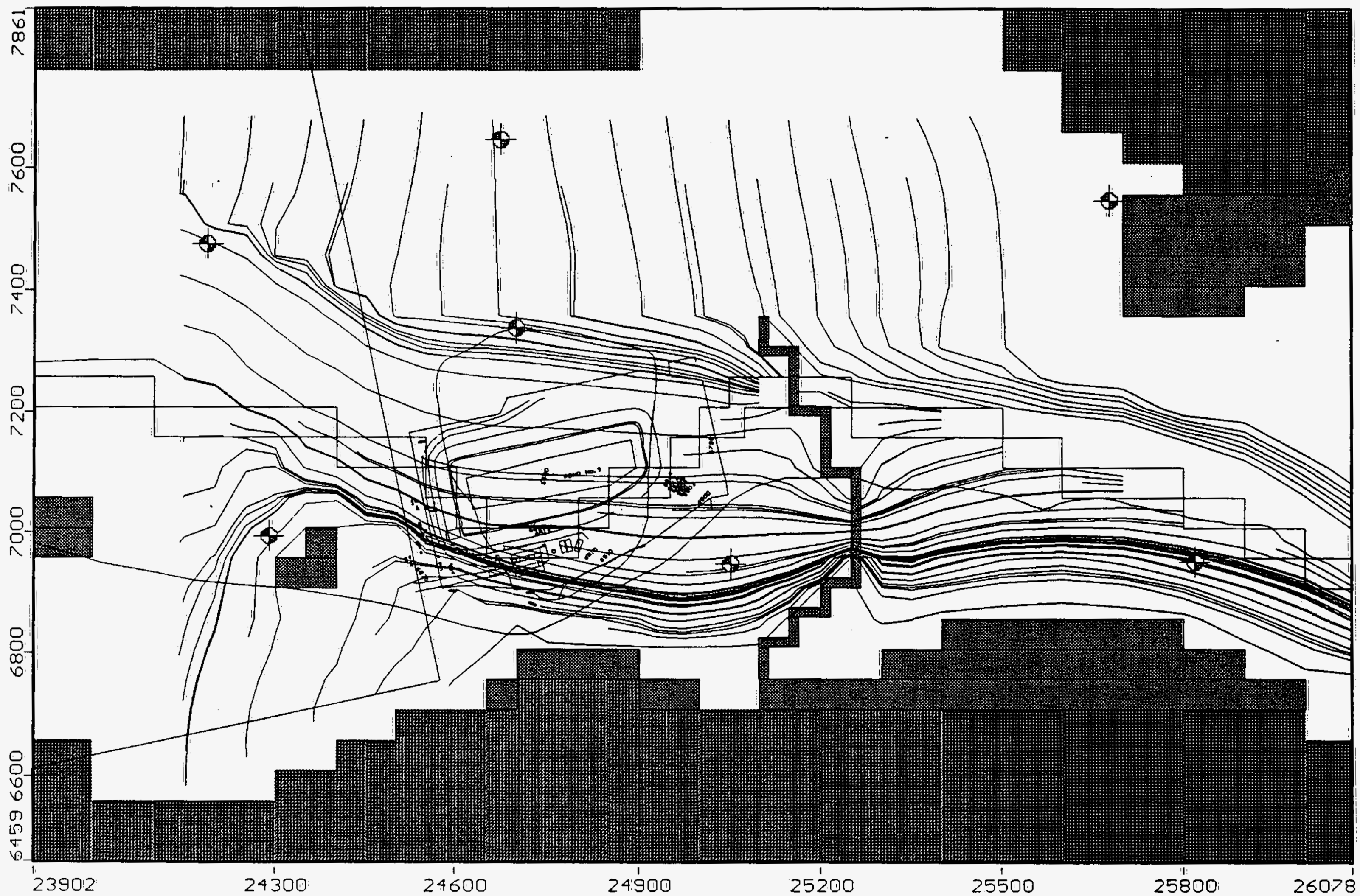
Mactec
Project: Monticello PeRT
Description: PERT7C wall location
Modeller: MACTEC
5 Jan 99

Visual MODFLOW v.2.7.2. (C) 1995-1997
Waterloo Hydrogeologic, Inc.
NC: 226 NR: 78 NL: 1
Current Layer: 1



Mactec
Project: Monticello PeRT
Description: PERT7C heads [ft]
Modeller: MACTEC
5 Jan 99

Visual MODFLOW v.2.7.2, (C) 1995-1997
Waterloo Hydrogeologic, Inc.
NC: 226 NR: 78 NL: 1
Current Layer: 1



Mactec
Project: Monticello PeRT
Description: PERT7C paths
Modeller: MACTEC
5 Jan 99

Visual MODFLOW v.2.7.2, (C) 1995–1997
Waterloo Hydrogeologic, Inc.
NC: 226 NR: 78 NL: 1
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Appendix D

Attachment D

Preliminary Montezuma Creek Alignment

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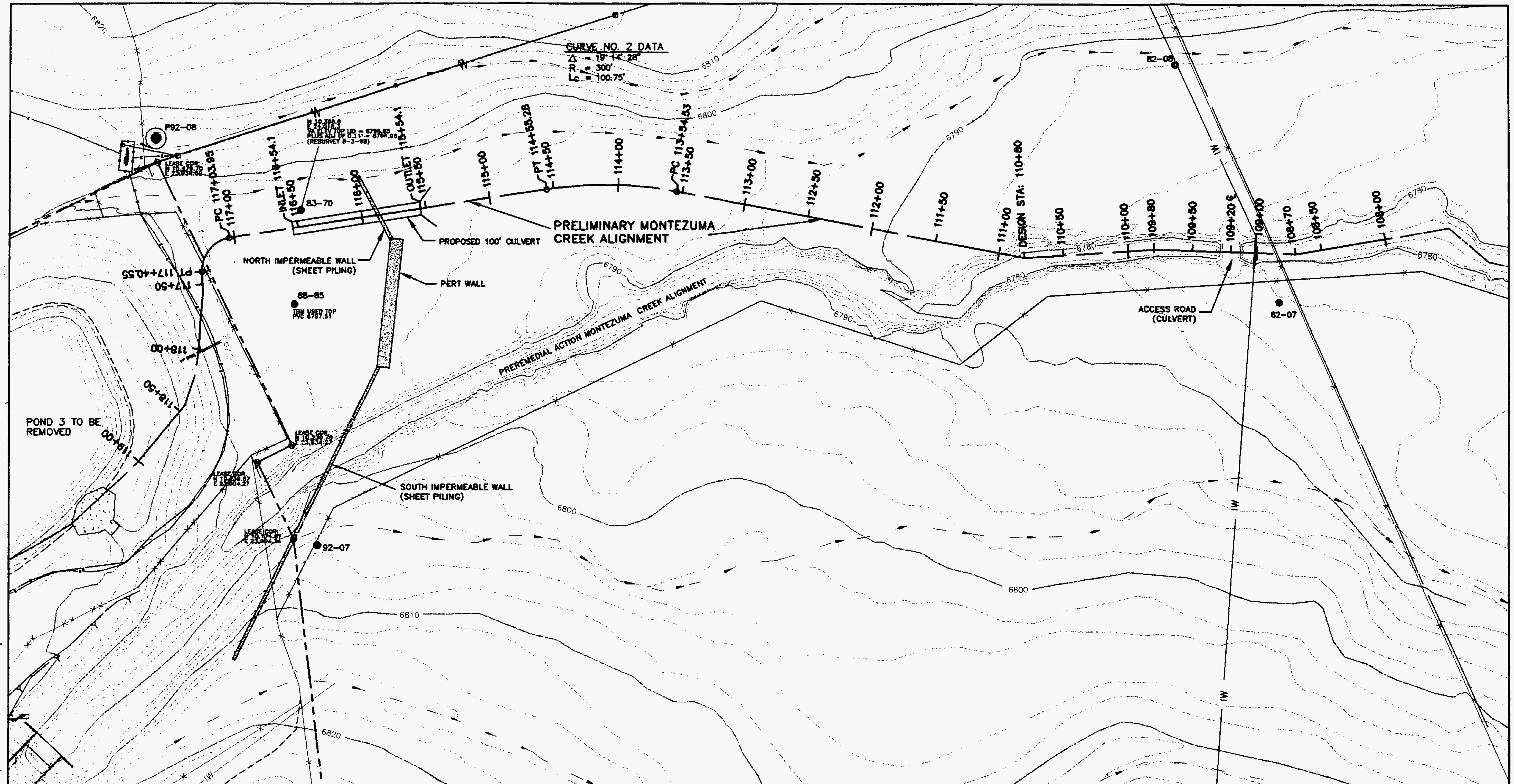

PRELIMINARY MONTEZUMA CREEK ALIGNMENT

N

SCALE IN FEET

100 50 0 100 200 300

CONTOUR INTERVAL = 2 FEET

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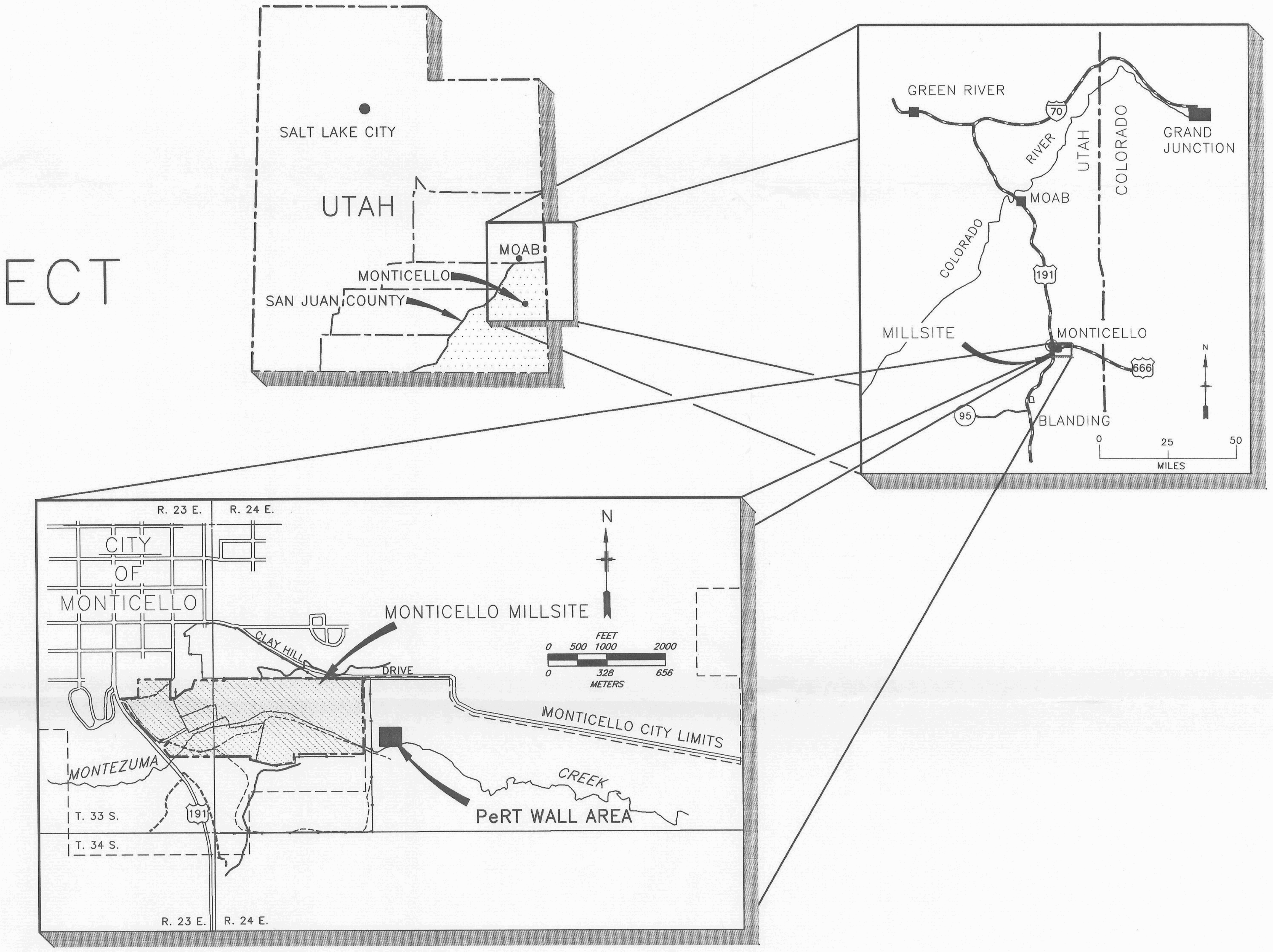
macTec-ers	U.S. DEPARTMENT OF ENERGY GRAND JUNCTION OFFICE GRAND JUNCTION, COLORADO
Figure 1	PRELIMINARY MONTEZUMA CREEK ALIGNMENT
DATE PREPARED: JANUARY 25, 1999	FILENAME: K00052AA

ZONE	REV	DESCRIPTION	DATE	APPROVED
		REVISIONS		

MONTICELLO MILLSITE
PeRT WALL DEMONSTRATION PROJECT

MONTICELLO, UTAH



DRAWING NUMBER	INDEX
1. K0002401	INDEX/TITLE SHEET
2. K0002801	SITE PLAN
3. K0002601	TREATMENT SYSTEM PROFILE
4. K0002701	PIPING DETAIL

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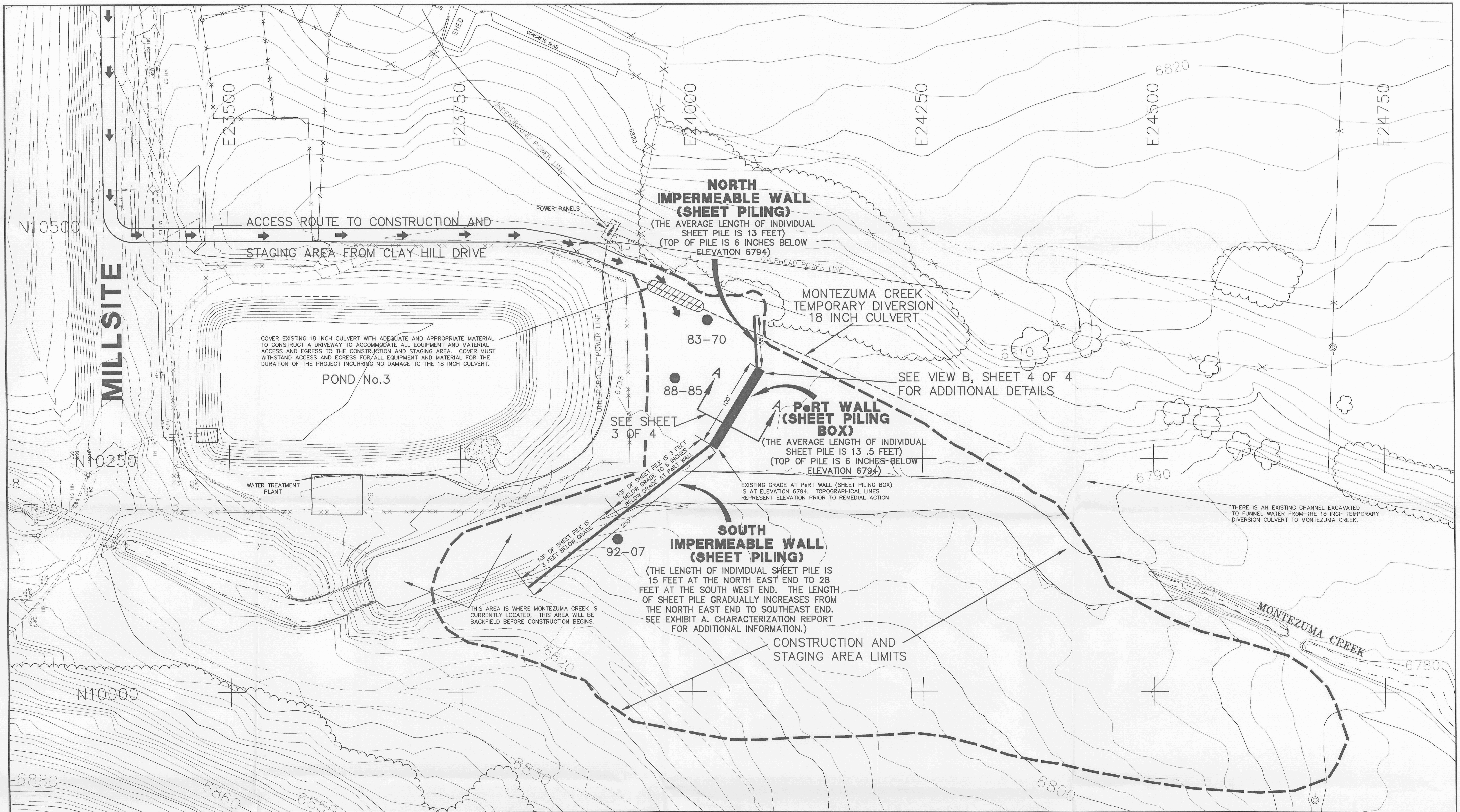
U.S. DEPARTMENT OF ENERGY
GRAND JUNCTION OFFICE, COLORADO

PROJECT LOCATION	APPROVALS	DATE	
MONTICELLO, UTAH	DESIGNER	12/21/96	PeRT WALL SPECIFICATION PACKAGE
	CAD TECH	12/12/96	INDEX/TITLE SHEET
	PROJECT ENGINEER		
REFERENCE: ORIGINAL DRAWINGS PREPARED BY SANDIA NATIONAL LABORATORIES ALBUQUERQUE, NM SUBSEQUENT DRAWINGS PREPARED BY MACTEC-ERS GRAND JUNCTION, COLORADO	ACCEPTED FOR CONSTRUCTION	12/21/98	
	SUBMITTED		PROJECT NO. PTW-121-0002-00-000
	DOE CONCURRENCE	21/Dec 98	DRAWING NO. K0002401
	OTHER CONCURRENCE		SHT. 1 OF 4



LEGEND

88–85 ●	PROTECT EXISTING WELLS
	TREE/BRUSH
	CONSTRUCTION AND STAGING AREA LIMITS
	ACCESS ROUTE TO CONSTRUCTION AND STAGING AREA
	FENCE

N

SCALE IN FEET

50 25 0 50 100 150

CONTOUR INTERVAL = 2 FEET

U.S. DEPARTMENT OF ENERGY GRAND JUNCTION OFFICE, COLORADO			
PROJECT LOCATION: MONTICELLO, UTAH	APPROVALS		PeRT WALL SPECIFICATION PACKAGE
	DESIGNER	DATE 12/21/98	SITE PLAN
	CAD TECH	12/21/98	
REFERENCE: ORIGINAL DRAWINGS PREPARED BY SANDIA NATIONAL LABORATORIES ALBUQUERQUE, NM SUBSEQUENT DRAWINGS PREPARED BY MACTEC–ERS GRAND JUNCTION, COLORADO	PROJECT ENGINEER		
	ACCEPTED FOR CONSTRUCTION	12/21/98	
	SUBMITTED		PROJECT NO. PTW–121–0002–00–000 — SHT. 2 OF 4
	DOE CONCURRENCE	21 Dec 98	DRAWING NO. K0002801

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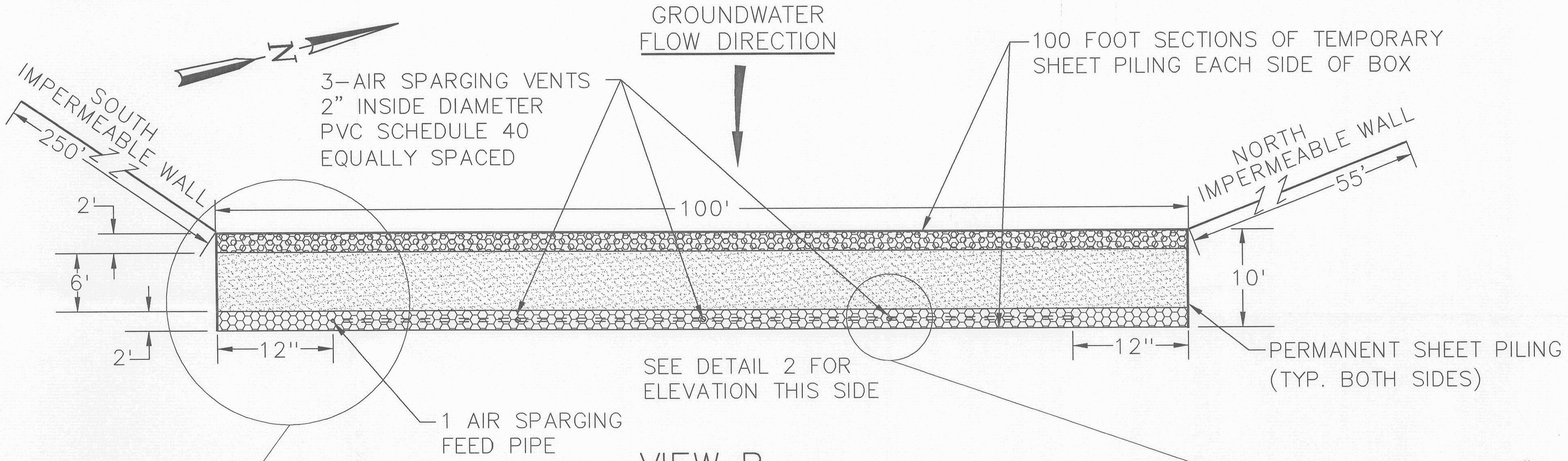
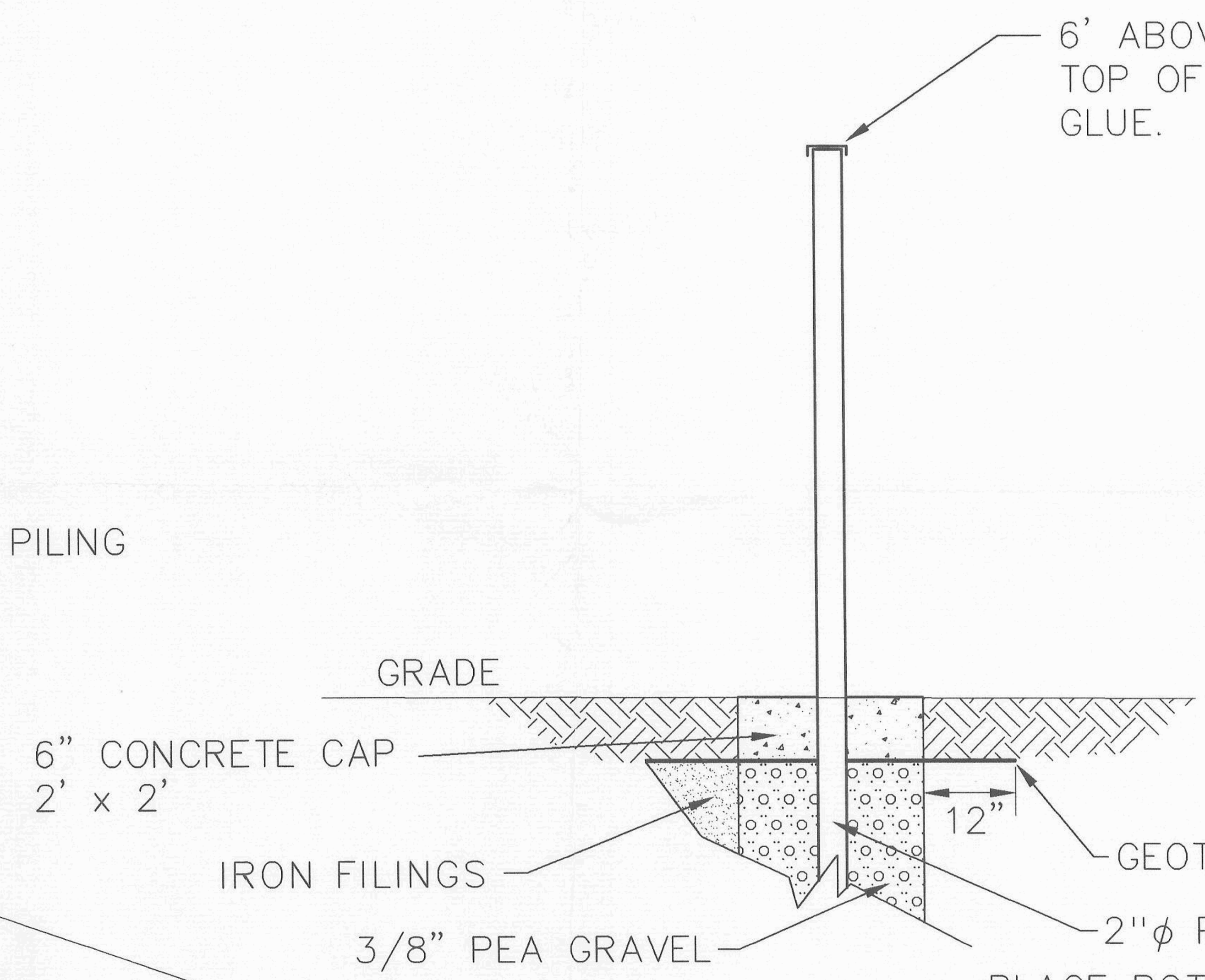
REVISIONS
ZONE
REV
DESCRIPTION
DATE
APPROVED
2 INCH INSIDE DIAMETER AIR SPARGING PIPE. CUT OFF 6 FEET ABOVE GRADE AND CAP (SEE DETAIL 1 ON SHEET 4 OF 4)
APPLY GEOTEXTILE TO TOP OF PeRT WALL LAP 12 INCHES AT ALL SEAMS. PLACE 12 INCHES BEYOND EDGES OF PeRT WALL AFTER SHEET PILING IS REMOVED.
SEE VIEW B AIR SPARGING DETAIL SHEET 4 OF 4
KEY TRENCH
EXISTING GRADE IS AT APPROXIMATE ELEVATION 6794
GRADE
0'
0.5'
1'
2'
3'
4'
5'
5.5'
10.5'
11.5'
12.5'
13.5'
CONTAMINATED GROUND WATER FLOW
BEDROCK AQUITARD
(VARIES FROM 10.5' TO 12.5' BELOW GRADE AT PeRT WALL)
LOCATE AIR SPARGING HORIZONTAL FEED PIPE 1 FOOT FROM THE BOTTOM OF EXCAVATION
SHEET PILING TO BE REMOVED AFTER IRON FILINGS TREATMENT MEDIA AND 3/8 INCH PEA GRAVEL ARE INSTALLED
LEGEND
IRON FILINGS TREATMENT MEDIA
3/8 INCH PEA GRAVEL
10 % BY VOLUME COARSE ZERO VALENT IRON IN 3/8 INCH PEA GRAVEL UNIFORMLY MIXED
1'
2'
2'
6'
PeRT WALL
SCALE: 4X
SECTION A–A
TREATMENT SYSTEM PROFILE
VERTICAL SCALE: 1"= 1'
HORIZONTAL SCALE: 1"= 10'
M:\PTW\121\0002\K0002601.DWG 12/16/98 11:29am J50191
U.S. DEPARTMENT OF ENERGY
GRAND JUNCTION OFFICE, COLORADO
PROJECT LOCATION
MONTICELLO, UTAH
REFERENCE
ORIGINAL DRAWINGS PREPARED BY SANDIA NATIONAL LABORATORIES ALBUQUERQUE, NM
SUBSEQUENT DRAWINGS PREPARED BY MACTEC–ERS GRAND JUNCTION, COLORADO
APPROVALS
DESIGNER
DATE
12/21/98
CAD TECH
12/21/98
PROJECT ENGINEER
ACCEPTED FOR CONSTRUCTION
12/21/98
SUBMITTED
DOE CONCURRENCE
21 Dec 98
OTHER CONCURRENCE
PeRT WALL SPECIFICATION PACKAGE
TREATMENT SYSTEM PROFILE
PROJECT NO. PTW–121–0002–00–000
DRAWING NO. K0002601
SHT. 3 OF 4



VIEW B AIR SPARGING DETAIL

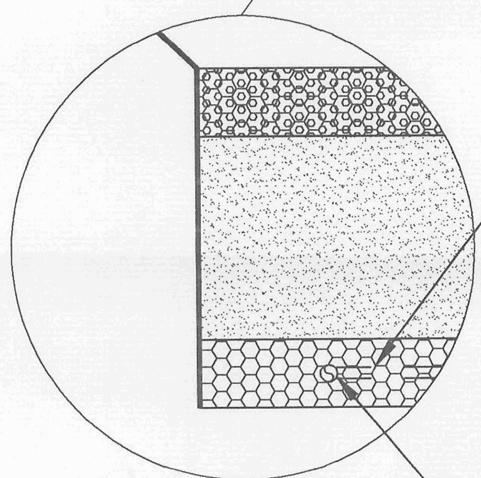
NTS



DETAIL 1

NTS

TYPICAL AIR SPARGING SURFACE COMPLETION DETAIL



AIR SPARGING VERTICAL AND HORIZONTAL FEED IS PVC SCHEDULE 40 PIPE. LOCATE HORIZONTAL PORTION OF AIR SPARGING FEED PIPE IN 3/8 INCH PEA GRAVEL OF PeRT WALL, 1 FOOT FROM BOTTOM OF EXCAVATION. LOCATE HORIZONTAL PIPE 1 FOOT FROM EACH END OF THE PeRT WALL. GLUE A CAP ON THE NORTH END. JOIN VERTICAL PORTION OF FEED PIPE WITH A GLUED ELBOW. DRILL FOUR 3/16 INCH HOLES 90 DEGREES APART AROUND THE 2 INCH CIRCUMFERENCE OF THE PIPE 6 INCHES ON CENTER THE LENGTH OF THE HORIZONTAL PIPE. SEE DETAIL 1 FOR SURFACE COMPLETION AND DETAIL 2 FOR ELEVATION VIEW AND DIMENSIONS.

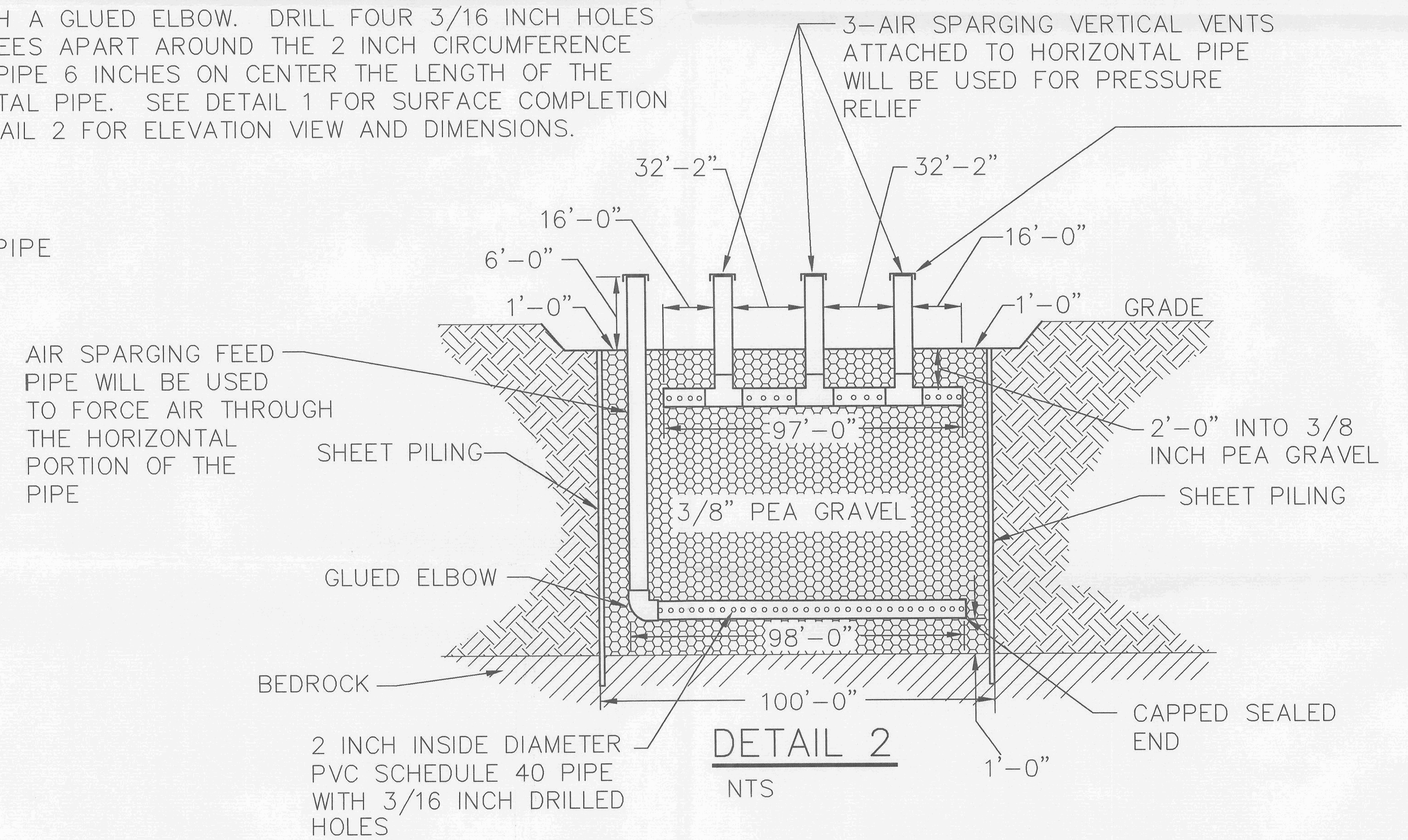
AIR SPARGING FEED PIPE

DETAIL 3

NTS

LEGEND

- IRON FILINGS TREATMENT MEDIA
- 3/8 INCH PEA GRAVEL
- 10 % BY VOLUME COARSE ZERO VALENT IRON IN 3/8 INCH PEA GRAVEL UNIFORMLY MIXED



DETAIL 2

NTS

VERTICAL VENT PIPES AND HORIZONTAL PORTION OF AIR SPARGING VENTS ARE 2 INCH INSIDE DIAMETER PVC SCHEDULE 40 PIPE. GLUE CAPES ON EACH END OF HORIZONTAL PORTION OF PIPE. CONNECT VERTICAL VENT PIPES TO HORIZONTAL PIPE WITH GLUED TEES. DRILL FOUR 3/16 INCH HOLES 90 DEGREES APART AROUND THE 2 INCH CIRCUMFERENCE OF THE PIPE 6 INCHES ON CENTER THE LENGTH OF THE HORIZONTAL PIPE. SEE DETAIL 1 FOR SURFACE COMPLETION AND DETAIL 2 FOR ELEVATION VIEW AND DIMENSIONS.

ZONE	REV	DESCRIPTION	DATE	APPROVED

REVISIONS

M:\PTW\121\0002\K0002701.DWG 12/01/98 5:08pm J50191

U.S. DEPARTMENT OF ENERGY
GRAND JUNCTION OFFICE, COLORADO

PROJECT LOCATION: MONTICELLO, UTAH

REFERENCE: ORIGINAL DRAWINGS PREPARED BY SANDIA NATIONAL LABORATORIES ALBUQUERQUE, NM SUBSEQUENT DRAWINGS PREPARED BY MACTEC–ERS GRAND JUNCTION, COLORADO

APPROVALS		DATE
DESIGNER	[signature]	12/21/98
CAD TECH	[signature]	12/21/98
PROJECT ENGINEER		
ACCEPTED FOR CONSTRUCTION	[signature]	12/21/98
SUBMITTED		
DOE CONCURRENCE	[signature]	21 Dec 98
OTHER CONCURRENCE		

PeRT WALL SPECIFICATION PACKAGE

PIPING DETAIL

PROJECT NO. PTW–121–0002–00–000
DRAWING NO. K0002701
SHT. 4 OF 4